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ABSTRACT

The logic and methodological concepts behind the application of a quantitative methodology to the problem of effective resource utilization in the New York State suburban schools is detailed. The goal of the study was to determine the best composition of available "factors of production," measured in dollar amounts by function, that would lead to a situation whereby school districts would produce a predetermined level of desired educational ends, while considering the students, community, teachers, and other educational attributes observed in the districts. This and other research problems were explored through application of a hybrid approach composed of economics and management science paradigms. Two empirical models were constructed. The first is descriptive, composed of 28 logistic equations, each of which portrays the quantitative relationships between school district resources and scholastic outcomes. A sample of 200 districts was used to calibrate this model. The second model is prescriptive; it is used to allocate the resources available within the districts so as to achieve the desired level of scholastic outcomes. A goal-programming technique was used in conjunction with the logistic equations to construct this model. Four scenarios were formulated to demonstrate the application of this model. Twelve tables, three charts, and a 127-item list of references are included. (Author/SLD)

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EDUCATION RESOURCES and OUTCOMES PROJECT

SCHOOL DISTRICT RESOURCES and TEST RESULTS: TWO APPLIED MODELS

LONG ISLAND REGIONAL PLANNING BOARD
HAUPPAUGE, NEW YORK 11788

SEPTEMBER 1989

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EDUCATION RESOURCES
and OUTCOMES PROJECT

SCHOOL DISTRICT RESOURCES and TEST RESULTS: TWO APPLIED MODELS

BY

DAVID SPOTTHEIM
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LONG ISLAND REGIONAL PLANNING BOARD
HAUPPAUGE, NEW YORK 11788

SEPTEMBER 1989

SCHOOL DISTRICT RESOURCES AND TEST RESULTS: TWO APPLIED MODELS

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THE SCHOOL DISTRICT RESOURCES AND TEST RESULTS: TWO APPLIED MODELS.

Hauppauge, N.Y., LIRPB, September, 1989

by

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ABSTRACT

This report details the logic and methodological concepts behind the application of a belated, but useful quantitative methodology to the problem of effective resource utilization within New York State suburban school districts. Hence, granted the egalitarian educational philosophy of the State of New York along with the emerging consensus regarding the needs to invest in human capital, and the availability of limited financial resources, this study's goal was to address the following predicament:

> What is the best composition of available "factors of production" (measured in dollar amounts by function) that would lead to a situation whereby various types of school districts would "produce" a predetermined level of desired educational ends, while considering the pupils, community, teachers, and other educational attributes observed in the districts.

This and other research problems were explored through the application of a hybrid approach composed of both economics and management science paradigms. Thus, two empirical models were constructed. The first model is "descriptive" in nature composed of 28 logistic equations. Each equation portrays the quantitative relationship between school district resources and a corresponding scholastic outcome "produced" by the districts. Resources in this instance include both financial resources controlled by the schools and community attributes beyond the school's control. Outcomes in this study were measured in terms of the probability that the districts will "produce" pupils who passed a score of state administered tests. A sample of 200 suburban school districts was used to calibrate this model.

The second model is "prescriptive" in nature, and as such, it was used to allocate the resources available within the districts so as to achieve the desired level of scholastic outcomes to be "produced" by the districts. A goal programming technique, was used in conjunction with the said logistic equations, to construct this model. To demonstrate the applicability of this model to the problem of resource allocation within school districts, four scenarios were formulated and solutions for these scenarios were derived. Each scenario represents a particular type of school district.

SCHOOL DISTRICT RESOURCES and TEST RESULTS: TWO APPLIED MODELS

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CHAPTER ONE

INTRODUCTION

I. HISTORICAL PERSPECTIVES

For almost one hundred years the State of New York has followed a constitutional obligation to provide and support free education to its children. To realize this obligation the New York State Legislative branch has used its prerogative and delegated part of the educational responsibilities to the school districts along with means to finance free education to children residing within the districts.

Recognizing that the educational resources available for pupils are predicated on whether they live in property rich or poor districts, the State of New York has attempted to minimize the horizontal inequalities (between districts) by supplementing the districts' budgets with state aid to education [see Cubberly, 1905; Strayer-Haig, 1923; Mort, 1933; and others cited in Cohn, 1974].*

Hence, in 1987 for example, 16.0 billion dollars were spent to provide and support free education to 2.57 million children of the State of New York [see "Financial Data for School Districts", June 1987]. However, despite the above mentioned obligation and legislative measures, the school districts have been faced with legal, scholastic, productivity and financial predicaments.

Recent court rulings have narrowed the definition of the said constitutional obligation while other rulings challenged the state aid to education policies. In the case of Levittown vs. Nyquist (1978) for instance, the court has stated that the said New York State obligation does not imply that free education constitutes a "fundamental constitutional right," whereas in a more recent court ruling, Judge Leflelt declared that the New Jersey State scheme of financing public education is "constitutionally flawed" [Sullivan in The New York Times, August 28 and September 6, 1988].

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*Sources cited are listed at the end of this report.

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In the mean time, the accelerating costs of public education and the concurrent increase of tax burden to finance these services along with the decline of pupils' test scores in recent years, all have intensified the debate concerning the relationships between educational outcomes and expenditures on public education services. Lately, this debate has been transformed into a public demand for improved services through the adoption of "effective" teaching methods and efficient resource utilization policies [see Fiske in The New York Times, August 24, 1987, and Shorr in WSJ Dec. 15, 1983]. Concurrently, various commissions were established to investigate the educational problems and their recommendations were widely reported in the printed media [WSJ Dec. 23, 1983; New York Times Nov. 13, 1983 and Feb., 1987]. In essence these recommendations call upon the public educational sector to implement policies such as:

- stiffer diploma requirements
- tougher academic standards
- improved teachers' qualifications
- improved guidance and counseling services
- longer hours in school.

While these recommendations have been considered as a means by which society can raise itself out of the current problems, they seem to contradict the egalitarian education philosophy of the State of New York, inasmuch as property poor districts may not have the necessary resources to realize these recommendations under the current resource allocation practices.

The lack of concern with the administrative and financial ramifications of these recommendations can be attributed to the prevailing view concerning the administrative practices of the educational system. Although expenditure of monies (on educational services) is being audited by the state, the prevailing notion is that accounting and management practices (used by the schools) do not lend themselves to evaluate the effectiveness of these expenditures [see Wohlfred, 1970]. This notion, however, can be challenged because the educational economics and management science literatures contain accepted theories and quantitative techniques that can be applied to the problem of efficacious utilization of educational resources for the purpose of realizing the desired scholastic goals or outcomes [see Fox, 1972; Enscore, 1972; Heim, 1972; Morgan, 1977; Bessent et al., 1982; Shapiro, 1984; Thomas, 1977; Spottheim/Libassi/Wilson, 1984].

Therefore, it is useful to examine the productivity and performance problems faced by the school through the application of quantitative research techniques found in the non-educational literature [Shapiro, 1984]. Such an examination is a novel approach to gain an insight into the operation of these organizations from a new prospective. The premise behind this approach is the notion that a contribution to any field of inquiry can have its origin in other fields [see Kuhn, 1970]. Hence, the educational sector may benefit from the adaptation of research paradigms developed in other fields for the purpose of examining analogous problems [see Bowles & Levin, 1968; Fox, 1972; Spottheim, 1974, 1975, 1988; Spottheim/Wilson, 1986, 1988; Thomas, 1962].

II. THE MAIN PROBLEM

Granted the egalitarian educational philosophy of the State of New York along with the emerging consensus regarding the needs to invest in human capital [Business Week, Sept. 19, 1988; Berger in The New York Times, Sept. 6, 1988; Carmody in The New York Times, Sept. 21, 1988], and the availability of limited resources, the universal educational challenge faced by the New York State school districts can be stated as follows:

> What is the best composition of available "factors of production" (manpower and available budget by functions), that would lead to a situation whereby particular type of school districts would "produce" a desired level of scholastic outcomes, while considering the pupils, community, teachers, demographic and educational attributes observed in the districts [see Bessent et al., 1982; Spottheim/Libassi/Wilson, 1984; Thomas, 1977].

Since the operational and budgetary problems behind this issue cannot be analyzed through the application of conventional or intuitive management practices, it is believed that proven methodologies found in the educational economics and management science fields of inquiry could be used in this instance. In using such quantitative techniques, both the educational resource allocation within school districts and the pupils' scholastic performances issues could be handled simultaneously.

III. THE APPROACH OF THIS STUDY

Granted the above research problem it can be argued that an empirical modeling approach composed of both educational economics and management science paradigms is the most suitable to address this topic. Such an approach can be defined as problem oriented research endeavor where hypothesized relationships which are based on theories are specified, tested empirically, and validated statistically, for the purpose of identifying regularities in the educational system in question [Harris, cited in Perloff, 1968].

According to this approach a school system is perceived to be a "firm" which strives toward the production of quality education. The advantage of this quantitative modeling approach is that it can tell us what scholastic achievement levels are attainable by pupils enrolled in a given school district. Also, it can tell us what cannot be expected from the school system in question. Moreover, it can provide us with the corresponding distribution of available financial and other educational resources needed to realize specific educational goals. Hence, a prior experimentation with costly demonstration projects is not necessary. Instead, information concerning the "best mix" of available educational resources (by functions) needed to realize the attainable (and desired) educational ends (pupil performance levels or educational goals) could be generated by this approach. These ends could be measured with respect to state administrated examinations. The educational resources (means) on the other hand, could be measured in terms of expenditure (per pupil) spent on functions such as:

- administration/planning/research
- instructional salaries
- non-instructional salaries
- equipment, supplies, materials
- contractual services
- pupil and community services
- overhead functions.

In addition to the above, variables depicting teachers, schools, pupils and community attributes beyond the control of the school district should be included in the research effort to explain the variation in the education outcomes.

Thus, two major models were constructed. The first is a descriptive model composed of 28 logistic equations, each portraying the technical relationships between educational expenditures incurred, and a score of educational outcomes "produced" by the school districts. And as such, this model is a representation of reality as conceived by the underlying theories and/or paradigms. A resource allocation (goal programming) model was then constructed and used to determine the best composition (or mix) of a school's available resources needed to ascertain the desired level of prioritized educational ends or outcomes.

This modeling approach is somewhat similar to the strategic planning analysis used to enhance the performance and productivity of educational systems as was suggested by Morrison (1985 Vol. 13, No. 2), Monk (1980), and demonstrated by Bessent (1982), Cohn & Millman (1975), Enscore (1972), Heim (1972), Spottheim, Libassi and Wilson (1984), and others. In this study just as in the strategic planning research approach, data regarding the operational environment is used in conjunction with quantitative methods and in the context of the system's missions while constructing empirical models portraying the relationships between educational means (resources) and ends (scholastic achievements).

IV. THE PARADIGM BEHIND THIS STUDY

The paradigm behind this empirical modeling effort is a blend of theoretical concepts advocated by Fox (1972) and quantitative techniques adopted from the econometric and management science fields of inquiry.

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The econometric technique, however, was tempered with biostatistical concepts regarding logistic modeling. In using this amalgamated approach arrays of administrative, financial, demographic and scholastic data were reduced to a manageable set of validated equations, thereby allowing us to gain a better understanding of productivity and performance problems faced by the school districts.

Accordingly, the school districts were perceived to be "firms" operating in a non-market environment, whose single "mission" is to deliver free education to their respective children. Hence, the services rendered by the schools are "publicly induced collective goods" inasmuch as the educational services are financed by one segment (taxpayer) and benefit another segment of society [Fox, 1972]. Since the school districts are operating in a "non-market" environment, they lack the incentive of utilizing their resources efficaciously [see for example, Fiske in The New York Times, Aug. 31, 1988]. Therefore, concepts and quantitative techniques advocated by Fox (1972) were used to explore the aforementioned educational problem.

A. The Non-Market Firm Theory

The non-market firm theory as was advocated by Fox (1972), Cohn (1975), and others, can be classified as a hybrid of the well-known economic Theory of the Firm and of Cobb-Douglass (1928) Production Function theory. In his book, Fox has provided a unique perception regarding such a firm along with complementary quantitative techniques that can be used to evaluate the operation of educational and training institutions, and other public entities.

According to Fox, a non-market firm is an enterprise or institution whose financial revenue is not derived directly from the goods and services it produces. In contrast, firms operating in a market economy must procure and allocate needed factors of production (e.g., labor, equipment, investment, and raw material) efficiently, if they wish to produce a level of output demanded by the market and to survive in the contemporary, avaricious and market-centered economy. Such firms are viable as long as their revenue is greater than their expenses. On the other hand, educational entities like school districts, for example, do not face such challenges; they can always use the option of raising taxes, increasing tuition, or requesting an increase in state aid for education to cover increases in the operational costs [adapted from Spottheim, Oct. 28, 1988].

Since its inception in 1972, this theory has been used by numerous researchers to analyze educational and governmental entities. Cohn (1975), Morgan and Cohn (1977), Spottheim/Libassi/Wilson (1984) used this theory to analyze educational entities, whereas, Spottheim and Wilson (1986-1988) have been using this theory in conjunction with management science techniques to address productivity problems faced by governmental entities in the State of Maryland.

B. The Complementary Techniques

The techniques used in this study were chosen because of their unique properties. Specifically, the logistic regression [see Schlosselman, 1982] and the goal programming [see Ignizio, 1982] techniques were used because they contain properties that simplify the construction of parsimonious models which are capable of providing voluminous information derived from a minimum number of statistically validated variables.

Also, the logistic and goal programming models are respectively "descriptive" and "prescriptive" in nature. Therefore, it was felt that their joint application will tell us what performance and productivity level are achievable and what cannot be expected from the school systems. Hence, a prior experiment with alternative and costly educational concepts was avoided. In addition, it was felt that these models are the most suitable to address the aforementioned educational research problem.

Recall that the said problem and the non-market firm theory implicitly call for the examination of the school districts' productivity and performance problems simultaneously. Traditionally a productivity analysis on the "firm's" level is aimed towards achieving an efficient utilization of "factors of production" for the purpose of ascertaining desired level of "outputs" (or outcomes) production, rather than dealing merely with the intensity of work [see Spottheim, Oct. 28, 1988].

To achieve the desired increase in productivity, one must investigate both the tactical and the strategic aspects of production planning. The tactical aspects call for enhancing the effectiveness in which a given set of equipment and the corresponding group of workers realize the production objectives of the "firm". The strategic aspect, on the other hand, is concerned with altering both the number of workers in the team and the range of equipment and other resources they need to produce the desired level of outputs [Greenborough cited in Bailey, 1981].

However, the strategic aspects of a non-market firm like a school district must also cope with the universal educational problem mentioned earlier. Hence, this type of planning analysis must be concerned with the quality of outputs (rather than the quantity of outputs) produced and the corresponding resources requirement simultaneously, as was advocated by Murnane (1975), Thomas (1962), and Spottheim/Libassi/Wilson (1984). In sum, the aforementioned techniques were chosen because they complement both Greensborough's notion of strategic planning and Fox's nonmarket firm theory. They were also chosen because of their unique quantitative properties.

C. The Limitations of This Study

While the amalgamated modeling approach used in this research endeavor can handle the just discussed strategic planning problems, it does have some limitations. Specifically, this study deals with the economics of resource allocation on the school district level, as was dictated by readily available machine readable data. Since the units of analysis of this study are school districts, this study ignores the issues of: a) individual student's test scores and the corresponding resources requirement; and b) resource allocation within classrooms as was analyzed by Murnane (1975) while using an econometric approach, and explored by Spottheim/Wilson through the application of an operation research technique [see Spottheim et al, 1984, Chapter IV]. Also, unlike earlier models, this model is composed of a set of multiple regression equations rather than as a system of simultaneous equations as was advocated by Boardman (1977) and Cohn (1975) and others. It was felt that a simultaneous system of logistic equations is methodologically inappropriate [see Fienberg, 1980]. Finally, a goal programming resource allocation procedure was used to explore the attainability of educational achievement targets rather than other methods [see Bessent, 1982; Banker, 1986]. The lack of time, resources and readily available computer programs precluded the application of such alternative methods.

D. The Theme and Structure of This Report

This report details the theoretical methodological concepts behind the application of a useful modeling approach used to address productivity, performance, and resources utilization problems faced by school districts in the State of New York. Hence, over 400 expenditure items along with scores of test results indicator and dozens of nonfinancial indices were culled from eclectic state administrative sources for approximately 200 suburban school districts located in eight New York State counties.* This raw data was then translated into the appropriate machine readable form. Consequently, the raw data was analyzed through the application of multivariate statistical methods, and this raw data was aggregated into a data base containing 135 variables and approximately 170 observations (school districts).

This data base was used to construct a logistic model composed of 28 equations. Each of the equations shows the technical relationships between a particular scholastic outcome and a set of explanatory variables. An outcome in this instance is measured in terms of a probability that a school district will produce pupils who pass a given state administrated exam. Consequently, these equations were used in conjunction with a resource allocation technique (goal programming) and that data base for purpose of estimating the amount of financial resources needed to achieve a desired level of educational outcomes for various types of districts.

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*These counties are: Dutchess, Erie, Herkimer, Monroe, Nassau, Oneida, Rockland and Westchester.

Since this expository report is addressed to a diverse audience, the theoretical, methodological and applied research concepts, instead of the quantitative aspects of this study are emphasized throughout this report. Thus, the remainder of this paper is structured as follows: in Chapter Two the logistic model is presented. The application of the goal programming technique (in conjunction with this model) is presented in Chapter Three. Finally, the summary of this endeavor can be found in Chapter Four.

2

SCHOOL DISTRICT RESOURCES & OUTCOMES RELATIONSHIPS: A LOGISTIC MODELING APPROACH

I. INTRODUCTION

II. AN OVERVIEW OF THE SCHOOL SYSTEMS
  A. The Decision-Making Environment
  B. Operational Structure and Processes
  C. Resources and Products

III. THE CONCEPTUAL MODEL
  A. The Theoretical Form of the Model
  B. Mathematical Transformation
  C. Calibration Methods and Statistical Considerations

IV. AN EMPIRICAL LOGISTIC MODEL
  A. The Data and Calibrations
  B. The Equations of the Model
  C. Inferences That can be Drawn From the Model
  D. Improvement of the Model

V. SUMMARY

CHAPTER TWO

SCHOOL DISTRICT RESOURCES AND SCHOLASTIC OUTCOMES RELATIONSHIPS A LOGISTIC MODELING APPROACH*

I. INTRODUCTION

Traditionally, free public education has been perceived as an egalitarian social obligation whose aim is to equip children with the necessary knowledge for their future roles as citizens in a democratic society and competitors in a market centered economy [see Keynes, 1932; Peterson, 1973].** Granted this view, the legislators of the State of New York have used their prerogative and delegated the implementation of this obligation along with a significant portion of the financial means to local educational jurisdictions (school districts). Thus, public education is said to be a "publicly-induced collective good" because it is financed by one segment of society (taxpayer) and benefits another [see Fox, 1972; Cohn, 1975]. Recognizing that the educational resources available for pupils depends on whether they live in a property-rich or poor district, the legislators have attempted to minimize the "horizontal inequities" (between districts) by supplementing the budget of the districts through state aid [see Cubberly, 1905; Strayer Haig, 1923; Mort, 1933 and others, cited in Cohn, 1974]. Despite this legislative measure, some inequity and productivity problems regarding the utilization of financial resources have been explored by concerned parties.

Until recently, inquiries concerning educational finance problems were confined to the problem of inequality of resource distribution, rather than with the amount of resources needed to realize desired educational goals or preemptive scholastic outcomes [see Cohn/Millman, 1975]. This inequity problem was examined by courts, commissions and researchers alike.

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* This chapter is an edited version of an earlier working paper (No. 2) with a similar title by Spottheim/Libassi (Sept., 1988).

** Cited sources are listed at the end of this report.

While the issue of the establishment of standards for equal financial treatment of children's education was raised in certain court cases [see Serrano vs. Priest, 1976; Robinson vs. Cahill, 1973; Levittown vs. Nyquist, 1978; San Antonio vs. Rodriguez], a recent ruling by Judge Steven L. Leflelt declared that the N.J. State's scheme of financing public education is "constitutionally flawed" [see Sullivan in The N.Y. Times, Aug. 28 and Sept. 6, 1988].

On the other hand, the commissions' preoccupation was confined to the tasks of identifying perceived problems and suggesting some administrative remedies, to the equity problems [see Fleischman, *et al.*, 1972; Gerber, *et al.*, 1979; Rubin, *et al.*, 1982]. Concurrently, researchers have investigated the inequity phenomena, and reported their findings in various documents [Bezeau, 1979; MacMahon, 1978; Johns, 1976].

In the meantime, researchers in the fields of political economy and management science have developed various approaches to portray the behavior of various public services delivery systems. These approaches were developed for the purpose of determining the resource mix needed by the system in question to operate efficiently. In the course of examining such systems, they have employed techniques such as:

- Cost Benefit Analysis
- Planning Programming-Budgeting Systems (PPBS)
- Cost-Effectiveness Analysis
- Production Function Equation(s)
- Goal Programming

While the cost benefit analysis technique was used to evaluate various programs monetarily, this method was found to have fundamental problems inasmuch as the benefit of a particular public service is not easily measured (Welty 1971). PPBS techniques, on the other hand, have been used to identify and suspend publicly-funded programs which could not be justified in terms of both current demand and available resources (Hill, 1965). Cost effectiveness analyses techniques have been used to overcome the difficulties associated with the cost benefit analysis. According to Cohn (1972), this method is a useful tool for examining an educational program, specifically in a situation where an administrator must choose between two educational methods: a capital intensive and a labor intensive approach of teaching.

The production function approach is a method which has been used to establish the relationships between inputs (resources) used, and outputs produced by a given system. Unlike cost benefit analysis which calls for indices denoting the benefits of the various services rendered by the public system, this technique requires only information concerning inputs (resources or means) and outputs of the public system. Investigators have used this approach to analyze educational systems in particular. They have perceived the schools to be analogous to enterprises operating in a "nonmarket" economy [Fox 1972]. According to Morgan (1977), the first researcher to employ this approach was Thomas (1962), followed by a study by Coleman (1966). Other models were developed by Cohn (1968), Cohn and Milman (1975), Bieker (1973), Heim (72) and Wendling (1980), who have used non-financial variables as explanatory variables while constructing linear models. Spottheim/Libassi/Wilson (1984), on the other hand, have developed a logistic model whose explanatory variables include various expenditures per enrollee incurred by the school districts.

As of late, the production function models were also used in conjunction with linear-goal programming techniques to allocate (financial) resources for ascertaining predetermined scholastic objectives. Cohn (1977) and Morgan (1977), for example, have applied a linear goal programming technique to the problem of nonfinancial resource allocation within Pennsylvania school districts while Spottheim and Wilson (1984) have used linear goal programming methods to the problem of financial resource allocation, within selected school districts located in the Long Island region. The advantage of the goal programming technique lies in its ability to handle complex and conflicting objectives (i.e., scholastic targets or goals). This method, however, presupposes that school administrators can rank specific scholastic targets, hierarchically. This technique searches for a "satisficing" (rather than optimizing) solution concetning the mix of required resources to reach the desired goals or targets.

The purpose of this chapter is to present the results of an empirical modeling effort whose aim was to portray the technical relationships between educational means and ends (scholastic outcomes) through the application of a logistic regression technique. Hence, the structure of a recently calibrated logistic model composed of 28 equations, is presented in this chapter. The model was calibrated while using administrative and financial data of approximately 160 school districts located in the aforementioned eight New York State counties. Consequently, this model was used in conjunction with a goal programming technique to estimate the financial resources needed to ascertain desired scholastic outcomes by various types of districts.

Thus, the remainder of this chapter is structured as follows: Section II contains a brief overview of the educational system, whereas the conceptual model is presented in Section III. The calibrated empirical model (logistic) and its interpretation are presented in Section IV, while the summary of this research endeavor can be found in Section V.

II. AN OVERVIEW OF THE SCHOOL SYSTEMS

Being a "municipal jurisdiction", whose single mission is to provide free education to its children, the school district is said to be a nonmarket enterprise. Characteristic of this entity is that its revenues are not derived directly from the services it rendered. In contrast, a firm operating in a market economy must procure and allocate needed resources efficiently, if they wish to produce a certain level of outputs and to survive in a competitive market. School districts, on the other hand, do not face such a challenge; they can always use the option of raising taxes. As a result of this operational environment, the scholastic performances must be examined in context of the school districts; a) decision making environment, b) mandated missions and objectives, c) corresponding processes used to realize these missions, and d) resources used to attain the objectives.

A. The Decision-Making Environment

The symbiotic relationship between taxation and expenditure(s) has led to a situation whereby the school districts exhibit a decision-making pattern similar to firms which operate in a "non-market environment" [Fox 1972]. Characteristic of this situation is that although the districts produce multiple outputs (outcomes or "products") and use a variety of resources, their decision-making environment seems to be periodically influenced by conflicting interests, policies and opinions. Consequently, remedies for controversial predicaments (concerning resources and outcomes) tend to be anecdotal in nature suited for a particular occasion.

Hence, these solutions could hardly be substantiated theoretically inasmuch as they are "a compromise" of a collection of "intrinsic opinions" reflecting the concerned parties' taste and style regarding educational input/outcomes relationships [Cohn 1980]. In addition to this decision-making environment, the school systems are endowed with structural and operational attributes which are analogous to those found in other service delivery organizations [see Hasenfeld 1972; Spottheim 1975; Spottheim/Wilson 1988]. Finally, the term "firm" in this instance implies the existence of a) an organizational mission, along with; b) complementary structure; c) resource utilization processes; and d) outputs and/or outcomes.

B. Operational Structure and Processes

School districts are said to be a complex and purposeful service delivery system whose mandated goal is to equip the children with the necessary skills and knowledge for their future roles as citizens in a democratic society and competitors in a market economy [see Peterson 1973].

To realize this goal the districts are involved in prolonged and tedious processes whose objective is to "transform" the current status of the pupil into the status of a self-sufficient citizen. Hence, the provision of educational services is essentially composed of a set of educational and administrative actions taken in relation to the pupils with the intention of assisting them to accumulate the knowledge and skill necessary to function as citizens in a contemporary society. It should be noted that this view complements a New Jersey court decision [see Robinson vs. Cahill, cited in Peterson 1973].

C. Resources and Products

Granted the above mission and objective, the schools are said to produce a set of identifiable outputs. In this study however, scholastic outcome rather than output variables were used to represent the quality of the school's products.

An outcome in this instance is measured in terms of the probability that a school district will "produce" predetermined and measurable scholastic outcomes. Although these probabilistic outcomes could be used as quantitative indices to measure the so called "higher order reasoning" they do not measure what the "pupil actually learned." Nevertheless, it was decided to use these variables because indices depicting the latter concept are not ubiquitously available. The expenditures (per pupil) on the other hand, were used in this instance as explanatory variables to explain the variation of the outcome values across school districts.

Therefore, the multiple educational ends (outcomes) produced by the N.Y. State districts are said to be the probability that these districts would "produce" pupils who scored:

- above the state reference point (SRP) on various state administrated PEP exams
- above SRP on the state administrated PCT test
- a passing grade on the various RCT tests
- a passing grade on the Regents Business tests

- a passing grade on selected Regents Languages exams
- a passing grade on selected Regents Math tests
- a passing grade on the Regents Science examinations.

To generate these ends, school districts are said to employ financial and manpower resources as inputs. Such inputs can be denoted by per-pupil expenditure on:

- instructional salaries
- noninstructional salaries
- equipment, supply, material and textbooks
- contractual, BOCES, and other categorical services and programs
- overhead and other administrative expenditures.

In addition, nonfinancial expenditure variables were also said to influence the outcomes. Thus, it was hypothesized that indices denoting teachers, school, and socio-economic attributes will influence the outcomes. These outcomes, however, are said to be tempered by (qualitative) indices denoting pupil performance (or "quality" of pupils) in a previous year. It has been suggested in the literature that these indices depict attributes such as:

- expenditures per pupil
- school district size
- crowdedness (sq. ft. per pupil).
- number of books and titles in the school library
- teachers' qualifications, experience and salaries
- class size
- income per return
- socio-economic characteristics of the district [see Chang, 1980; Cohn & Kiker, 1967; Cohn et al., 1986; Katzman, 1971; Kuhns, 1972; McDonnel, 1982; Monk, 1980; Murnane, 1975; Reed, 1983; Thomas, 1962].

III. THE CONCEPTUAL MODEL

The preceding narrative concerning the structure and behavior of the educational jurisdictions can be expressed (symbolically) in a mathematical form. The advantage of this approach expression is that it also summarizes the conceptual overview of the system, statistical concepts along with relevant theories, and an array of administrative data into a manageable theoretical equation. Such an expression can then be used as the theoretical model, and consequently it could be calibrated and empirically tested. Such a mathematical expression has advantages of:

- explicitly illuminates the assumptions and definitions mentioned in the narrative
- rigorously defines relationships
- avoids the digression of vague arguments
- illuminates the shortcomings of the approach [Brennan 1965].

A. The Theoretical Form of the Model

The theoretical form of each equation was hypothesized to have a logistic (logit) structure, showing the relationships between the probability of achieving a certain outcome (by pupil enrolled in a given district) and the corresponding expenditures (per pupil) incurred by that district. It should be noted that this logistic equation is similar to an epidemiological model because the outcome and expenditures are analogously related to the concepts of "response" and "dose" (or stimulus) respectively. Since the probable outcome "i" (for school districts "j") in this model is said to be influenced by a set of expenditures ($FRV_{k,j}$) and other nonfinancial attributes ($TSCP_{1,j}$;

$COM_{m,j}$; $APNZ_{n,j}$), the theoretical logistic model can be expressed in the following mathematical form:

$$1.\quad O_{i,j} = 1/1+ (Exp) - a_i - \sum_{k=2}^{k} b_k FRV_{k,j} - \sum_{l=1}^{L} c_l TSCP_{l,j} - \sum_{m=1}^{M} d_m COM_{m,j} - \sum_{n=1}^{N} e_n APNX_{n,j} - U_{i,j}$$

Where;

$Q_{i,j}$ = dependent variable (to be forecasted) denoting the probability that an outcome "i" will be realized at a particular school district "j"

$FRV_{k,j}$ = input or financial expenditure variable under the control of the school district - an explanatory variable denoting expenditure (per pupil) by function "k" (i.e., salaries, expenditures on equipment, material, contractual, BOCES) of school district "j"

$TSCP_{l,j}$ = teacher or school characteristic index "l" - a nonfinancial explanatory variable observed in school district "j"

$COM_{m,j}$ = community index "m" - an explanatory variable denoting the socio-economic condition of school district "j"

$APNX_{n,j}$ = pupil performance index "n" (previous time period) observed in school district "j" - an explanatory variable

(Exp) = e = 2.71828. . . . . . .

a_i, b_k, c_l, d_m, e_n = parameters (coefficients) associated with their respective explanatory variables - their values could be determined (or calibrated) empirically.

$\sum$ = summation symbol

$U_{i,j}$ = a residual (or error term) associated with the outcome "i" and school district "j"

The probability variable O_{ij} can be derived through the aggregation of dichotomous variable "Y_{ij}", (denoting whether a pupil enrolled in school district "j" passed (or failed) state administrated test "i") and dividing the sum by the total no. of pupils (of that district) who took the test.**

It should be noted however, the theoretical model presented above is not a direct extension of the previously mentioned studies inasmuch as it portrays the relationships between the quality of the outputs produced (measured in terms of the probability of attaining a given level of outcome) and the expenditures incurred by the districts, as was advocated initially by Murnane (1975) and Thomas (1962). On the other hand, earlier econometric studies by Bieker (1973), Cohn (1975), Heim (1972), Katzman (1971), Morgen (1977), Wendling (1981), and others, dealt merely with the quantity of educational outputs produced. Hence, the quantification of these relationships has been achieved in this study through the application of a hybrid of theoretical concepts culled from a proven body of economic and biostatistical theories. Specifically, the "Non-market Firm Theory" [Fox 1972] in general, and "educational production function" concepts [Coleman 1966, Cohn 1975; Heim 1972; Spottheim *et al*. 1984] in particular, along with biostatistical concepts [Colquhoun 1971; Fienberg 1980; Schlosselman, 1982], all are embedded in this model. This theoretical equation has been used as a "guide" while specifying, calibrating and validating the 28 equations of the model.

**The value of O_{ij} for the various districts was derived as follows:

$$O_{ij} = \sum_{i=1}^{N_j} Y_{ij}/N_{ij}$$

Where;

Y_{ij} = 1, if a pupil enrolled in school district "j" passed the test "i", above SRP; otherwise $Y_{ij} = 0$

N_i = Total no. of pupils enrolled in school district "j" who took the "i^{th}" test.

B. Mathematical Transformation

The hypothesized equations were specified in a form which "mimics" the theoretical model (equation 1). This form, however, does not lend itself to the application of a calibration method. While the literature contains a variety of mathematical procedures that can be used for this purpose, it was decided to exclude all but one procedure.

For example, the use of a "linear probability function" was precluded because this form is known to generate "biased and inconsistent" results [see Zellner and Lee 1963]. The traditional "direct assays" form (used in biological studies) was found to be inappropriate because it calls for the specification of both dependent and explanatory variables as log (to base 10) variables [see Colquhoun 1971]. Such a specification also may hinder the forthcoming application of the logistic model in conjunction with the aforementioned resource allocation technique.

Therefore, the "hypothesized equations" of the model were "transformed" into a "logistic function," thereby allowing us to estimate the coefficients via a regression technique. Following the Chiswick (1975) and Theil (1971) writings, it can be shown that upon "transforming" these equations, they will have the same structure as the (transformed) theoretical model, shown below:

$$2. \quad Q_{ij} = \ln(O_{ij}/1-O_{ij}) = a_i + \sum_{k=2}^{k} b_k FRV_{k,j} + \sum_{l=1}^{L} c_l TSCP_{l,j} + \sum_{m=1}^{M} d_m COM_{m,j} + \sum_{n=1}^{N} e_n APNX_{n,j} + U_{i,j}$$

Where;

Q_{ij} = transformed dependent variable concerning the "i^{th}" outcome and "j^{th}" school

ln = natural log symbol

All other variables and parameters were defined earlier (see Eq. No. 1).

Notice that the left hand side of the above equation is analogous to the dependent variable in a multiple linear equation model, and this transformed equation lends itself to the application of a regression technique for the purpose of estimating the unknown value of the coefficients.

C. Calibration Methods and Statistical Considerations

A calibration task can be defined as an effort to produce quantitative relationships between a probable educational outcome and a set of nonstochastic explanatory variables. The equations produced by this effort could then be used to draw policy-oriented inferences concerning the resource/outcomes relationship of the system. These equations could also be used in conjunction with a goal programming technique, as was suggested by Fox (1972) and by Cohn (1975) demonstrated by Cohn and Morgan (1977), Morgan (1977), and Spottheim/Wilson (1984).

To realize this empirical aim, alternative calibration procedures could be employed. For example, the logistic (transformed) equations could be calibrated via a "Weighted Least Squares" (WLS) method, or a maximum likelihood (ML) technique to estimate the value of the logistic coefficients. Even the classical OLS could be used for this purpose inasmuch as it was found in this research endeavor and in a previous educational research project, that the ML technique produced coefficients whose numerical value was not significantly different from those produced by the OLS technique [also see Spottheim/Libassi/Wilson 1984].

Finally, the literature suggests that an educational production function model be composed of a "semi-endogenous system of equations" inasmuch as the outcome variables are said to be jointly dependent [see

Boardman, 1977; Cohn, 1975]. In such a case an output variable can enter as a "dependent variable" in an equation and enter into a successive equation as an "endogenous-explanatory" variable [Spottheim, 1980, 1983]. Biostatisticians dubbed such a model as a "causal linked nonrecursive system of equations" [Fienberg, 1980]. However, a "nonrecursive system of logistic equations" must not be calibrated [Fienberg, 1980]. The rational behind this statement is that a probabilistic dependent variable cannot be used concurrently as a "response" and explanatory variable [Brier, 1978, cited in Fienberg, 1980]. Because of this methodological assertion, an earlier attempt to construct a static nonrecursive system of logistic equations was aborted [see Spottheim/Libassi/Wilson, 1984, p.II-12].

IV. AN EMPIRICAL LOGISTIC MODEL

To construct the data base for this research endeavor, over 400 school finance and accounting items along with a score of scholastic performance indicators and numerous nonfinancial indices were culled from eclectic administrative sources for approximately 200 school districts. This "raw" data base was then analyzed through the application of multivariate statistical methods (i.e., factor analysis, discriminate analysis) and aggregated into a set containing some 100 variables. Consequently, additional variables were constructed and a matrix composed of 165 cases (school districts containing both elementary and high schools) and 133 variables was created as the data base of this logistic model.

The variables of this data base are defined below in Table 2.1. A cursory examination of this table will reveal that it contains: a) financial resources which are under the control of the districts

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TABLE 2.1

LIST OF EXPLANATORY VARIABLES OF THE FINAL LOGISTIC MODEL

I. FINANCIAL EXPENDITURE DATA (SCH. A4 DATA) IN DOLLARS PER PUPIL

Var. No.	Var. Code	Definition	Formula
A. Chief School Administration Office			
X(1)	F (1)	Instructional Chief School Adm. (Per Total Enrollment)	= X'(1)/X (50)*
X(2)	F (2)	Total Chief School Adm.	= X'(2)/X (50)
B. Instruction, Administration & Improvement			
X(3)	F (3)	Instructional Salaries	= X'(3)/X (50)
X(4)	F (4)	Non-Instruct. Salaries	= X'(4)/X (50)
X(5)	F (5)	Equipment/Supply	= X'(5)/X (50)
X(6)	F (6)	Contractual + BOCES	= X'(6)/X (50)
X(7)	FA (7)	Total Curriculum Develop.	= X'(7)/X (50)
X(8)	FA (8)	Total Supervision	= X'(8)/X (50)
X(9)	FA (9)	Total Research/Education/Plan.	= X'(9)/X (50)
X(10)	FA (10)	Total Training	= X'(10)/X (50)
X(11)	FTA (11)	Total Instr./Administ./Improv.	= X'(11)/X (50)
C. Instructional Teaching			
X(12)	FIT (12)	Teachers Salaries K-6	= X'(12)/X (48)**
X(13)	FIT (13)	Teachers Salaries Total	= [X'(12) + X'(13) + X'(14)]/X (50)
X(14)	FIT (14)	Substitute Teacher Salaries	= X'(14)/X (50)
X(15)	FIT (15)	Non-Instructional Salaries	= X'(15)/X (50)
X(16)	FIT (16)	Equipment/Supply/Text Books	= X'(16)/X (50)
X(17)	FIT (17)	BOCES/Contractual/Tuition	= X'(17)/X (50)
X(18)	FTIT (18)	Total Instructional Teaching	= X'(18)/X (50)
D. Instructional Media			
X(19)	FM (19)	Instructional Salaries	= X'(19)/X (50)
X(20)	FM (20)	Non-Instructional Salaries	= X'(20)/X (50)
X(21)	FM (21)	Equipment/Supply	= X'(21)/X (50)
X(22)	FM (22)	BOCES/Contractual	= X'(22)/X (50)
X(23)	FTM (23)	Total Instructional Media	= X'(23)/X (50)

---

* X (50) = Total No. of Pupils

** X (48) = Elem. School Pupils

X'(i) = total expenditure for category "i" (i = 1,2,...,47)

Table 2.1 (Con't.)

Var. No.	Var. Code	Definition	Formula
E.	**Pupil Services (Guidance/Health/Psych./Soc. Work)**		
X(24)	FPS (24)	Instructional Salaries	= X'(24)/X (50)
X(25)	FPS (25)	Non-Instructional Salaries	= X'(25)/X (50)
X(26)	FPS (26)	Equipment/Supply	= X'(26)/X (50)
X(27)	FPS (27)	BOCES/Contractual	= X'(27)/X (50)
X(28)	FTPS (28)	Total Pupil Services	= X'(28)/X (50)
F.	**Pupil Services (Cocurricular/Interscholastic Athletic)**		
X(29)	F (29)	Instructional Salaries	= X'(29)/X (50)
X(30)	F (30)	Non-Instructional Salaries	= X'(30)/X (50)
X(31)	F (31)	Equipment/Supply	= X'(31)/X (50)
X(32)	F (32)	BOCES Serv./Contractual	= X'(32)/X (50)
X(33)	FCA (33)	Total Cocurricular	= X'(33)/X (50)
X(34)	FCA (34)	Total Interscholastic Athletic	= X'(34)/X (50)
X(35)	FTCA (35)	Total Cocurric./Athletic	= X'(35)/X (50)
G.	**Community Service & Recreation**		
X(36)	F (36)	Instructional Salaries	= X'(36)/X (50)
X(37)	F (37)	Non-Instructional Salaries	= X'(37)/X (50)
X(38)	F (38)	Equipment/Supply	= X'(38)/X (50)
X(39)	F (39)	BOCES/Contractual	= X'(39)/X (50)
X(40)	FCY (40)	Total Community/Recr.	= X'(40)/X (50)
X(41)	FCY (41)	Total Youth Program	= X'(41)/X (50)
X(42)	FCY (42)	Total Civic Activities	= X'(42)/X (50)
X(43)	FTCY (43)	Total Commun./Youth/Civic	= X'(43)/X (50)
H.	**Other Overhead Expenditures**		
X(44)	FTEB (44)	Total Emply. Benefit	= X'(44)/X (50)
X(45)	FTOM (45)	Total Operation & Maint.	= X'(45)/X (50)
X(46)	FTBUS (46)	Total Bus Transportation	= X'(46)/X (50)
X(47)	FT4546 (47)	Sum of [X(45) + X(46)]	= X'(47)/X (50)
II.	**TEACHERS, SOCIO-ECONOMIC & COMMUNITY CHARACTERISTICS OF THE DISTRICTS**		
X(48)	E (48)	K-6 Enrollments* (a size variable)	
X(49)	E (49)	7-12 Enrollments* " " "	
X(50)	E (50)	Total Enrollments	
X(51)	SQF (51)	Sq. Ft. of Classroom per Pupil (a crowdedness measurement)	
X(52)	TQ (52)	Av. Teacher Qualifications Index	= [Yrs.of Exp.+ 0.5 yrs.of ed.]
X(53)	PQ (53)	Av. Nonteaching Prof. Qualifications	
X(54)	ATS (54)	Av. Teachers' Salary	= [X'(12) + X'(13)]/X'(54)**
X(55)	PN (55)	No. of Nonteaching Professionals	
X(56)	IPR (56)	Income per Return (a wealth measurement)	
X(57)	IR (57)	No. of Tax Returns	

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*In the project data file E(48) and E(49) denote elementary and secondary school enrollments, respectively.

**X'(54) in this case denotes the total number of teachers in the district.

Table 2.1 (Con't.)

Var. No.	Var. Code	Definition	Formula
X(58)	IP (58)	Income per Pupil	$[X(56) * X(57)]/X(50)$
X(59)	BOOKS	No. of Books in School Library	
X(60)	TITLES	No. of Titles in School Library	
X(61)	PUTR	Pupils/Teachers Ratio	
X(62)	ACSCB	Avg. Class Size Common Branch (Elem.)	
X(63)	ACS8ESS	" " " Grade 8 English & Soc. Sci.	
X(64)	ACS8MSC	" " " " 8 Math & Sci.	
X(65)	ACS8GR	" " " " 8 (All subjects)	
X(66)	ACS10GR	" " " " 10 (All subjects)	
X(67)	ACS10ESS	" " " " 10 English & Social Sci.	
X(68)	ACS10MS	" " " " 10 Math & Science	
X(69)	BIR56A	Dummy (Binary) Income Var. A	$X(69)= 1$, if $X(56) < (\bar{X}(56) -0.5\ SD)$
X(70)	BIR56B	" " " " Var. B	$X(70)= 1$, if $X(56) > (\bar{X}(56) +0.5\ SD)$
X(71)	SOCEI	Socio-Economic Indicator	
X(72)	BISOC	Binary Socioeco. Indicator	$X(72)= 1$, if $X(71) > 6.45$, otherwise $= 0$
X(73)	PUPSSR	Pupil Support Staff Ratio	

III. TREND SCHOLASTIC PERFORMANCE - BINARY VARIABLES*

Var. No.	Var. Code	Definition
X(76)	P 3	Writing Grade 5
X(78)	P 5	Math Grade 6
X(79)	P 6	Reading Grade 8
X(80)	P 7	RCT-Math
X(81)	P 8	RCT-Reading
X(82)	P 9	RCT-Writing
X(86)	P 13	REG-Comp. English
X(93)	P 20	REG-Math 10

---

*The trend variables are (transformed) dummy variables. Hence, the value of a variable = 1 if the % of pupils (of a given school) who passed a particular exam is above statewide sample average, otherwise = 0. Only the dummy trend variables indicated above actually entered the final model as explanatory variables.

Table 2.1 (Con't.)
LIST OF DEPENDENT VARIABLES*

IV. EXAM RESULTS PROBABILITIES (1984-1985 SCHOOL YEAR DATA)

Var. Code	Definition	Formula
	TRANSFORMED DEPT. VARIABLES	
A. PEP Exams		
Q (1)	PEP-Reading Grade 3 above SRP	
Q (2)	PEP-Math " " "	
Q (3)	PEP-Writing Grade 5 " "	
Q (4)	PEP-Reading Grade 6 " "	
Q (5)	PEP-Math Grade 6 " "	
B. PCT Test		
Q (6)	PCT-Reading Grade 8 " "	
C. RCT Tests		
Q (7)	RCT-Math- Passed (June test only)	
Q (8)	RCT-Reading " " " "	
Q (9)	RCT-Writing " " " "	
D. Regents Business Tests		
Q (10)	REG-Bookkeeping (June test only)	
Q (11)	REG-Business Law " " "	
Q (12)	REG-Business Math " " "	
E. Regents Languages		
Q (13)	REG-Comp. English " " "	
Q (14)	REG-Comp. French " " "	
Q (15)	REG-Comp. German " " "	
Q (16)	REG-Comp. Italian " " "	
Q (17)	REG-Comp. Latin " " "	
Q (18)	REG-Comp. Spanish " " "	
F. Regents Math		
Q (19)	REG-Math 9 " " "	
Q (20)	REG-Math 10 " " "	
Q (21)	REG-Math 11 " " "	
Q (22)	REG-Seq. Math I " " "	
Q (23)	REG-Seq. Math II " " "	
Q (24)	REG-Seq. Math III " " "	

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*NOTE: The dependent variables of the logistic model are referred to throughout this paper by their code (Q_i).

Table 2.1 (Con't.)
LIST OF DEPENDENT VARIABLES*

Var. Code	Definition	Formula
	TRANSFORMED DEPT. VARIABLES	
G.	Regents Sciences/Social Sci./Dropout	
Q (25)	REG-Biology " " "	
Q (26)	REG-Chemistry " " "	
Q (27)	REG-Earth Science " " "	
Q (28)	REG-Physics " " "	
Q (29)	REG-Comp. Soc. Stud." " "	
Q (30)	Dropout	

consisting of (1) direct, (2) indirect, (3) overhead, and (4) administrative expenditures (per pupil) as was advocated by Stark cited in Bailey's Book (1980); b) other districts' attributes that are likely to influence the scholastic outcomes even though they are beyond the control of the school [see Kuhns, 1972; Cohn, 1975]; c) scholastic trend variables; and d) scholastic outcome variables. Specifically, *Table 2.1* contains:

- 47 financial expenditure (per enrollee) variables which can be manipulated by the districts.
- 26 variables depicting district, teacher and community attributes of which some of them are beyond the school's control.
- 8 variables denoting the scholastic performance trend.
- 30 dependent variables each denoting the probability that the school "produced" pupils which passed specific state administrated exams.

The first group of variables are measured in terms of expenditure per enrollee by 47 expenditure categories. A cursory examination of *Table 2.1* will reveal that these expenditure categories are presented under the headings of a) Chief School Admin.; b) Instruction Administration and Improvement; c) Instructional Teaching; d) Instructional Media; e) Pupil Services; f) Pupil Services - cocurricular, etc.; g) Community Services; and h) Other Overhead Expenditures. Notice that the grand total of these headings virtually cover the entire expenditures (per pupil) incurred by each of the sampled schools during 1984-1985 school year.

The second group of variables is a combination of continuous, discrete, and binary variables. For instance, variables no. 69-72 are essentially binary variables created to mitigate the multicollinearity problem, whereas variables nos. 48-51 are continuous variables used to mitigate the heteroscedasticity problem detected in the data base. On the other hand, variable no. 52 is a discrete measurement accounting for both teachers' education and experience.

The third group of variables is composed essentially of binary variables. Each of these variables has a value of 1 (one) if the school "produced" pupils whose exam score was above the statewide average, otherwise 0 (zero). These dummy variables were created to mitigate the multicollinearity problem. It should be noted that the aforementioned groups of variables were used as the explanatory (or independent) variables of the model.

Finally, the fourth group of variables are the dependent variables of the model. Each of these variables denotes the probability that the school "produced" pupils who passed specific state administrated exams. It should be noted, however, that for calibration purposes these (dependent) variables were transformed into a logistic function, as was depicted earlier in Section III-B (Eq. No. 2).

A. The Data and Calibration

Although the data base used to calibrate the logistic model consisted of approximately 200 cases (school districts), only those districts that had a minimum high school enrollment of 300 pupils were included in the final data sample. Furthermore, any school district whose total enrollment exceeded 9999 pupils was then deleted from the final data base. Consequently, the original data base was reduced by approximately 40 school districts.

Whereas the final data base consisted of approximately 160 districts and over 130 variables (for each district), the sample size used to calibrate the model varied from equation to equation. In other words, school districts containing no information regarding a particular exam results (for the 1984-85 school year) were deleted from the sample used to calibrate such equations. For instance, a sample size of 159 school districts was used to calibrate equation Q_1 (e.g. PEP Reading - 3rd Grade), whereas, a sample size of only 62 districts was used to calibrate equation Q_{24} (e.g. Regents Math III). However, no "outlier" districts were eliminated from the sample sizes. An outlier is said to be a case (district) whose residual lies over two standard deviations away from the mean of the residuals [see Draper, 1981, for details].

Finally, numerous variables in the data base have been adjusted in order to mitigate multicollinearity and heteroscedasticity problems encountered during the calibration phase. For instance, variable no. 71 (socio-economic indicator) was transformed into a binary variable (see variable no. 72) to mitigate a multicollinearity problem, whereas variables no. 48 and 49 have been added as "size" indicators to eliminate a heteroscedasticity problem. Also, all scholastic trend variables (nos. 76, 78-82, 86, 93) were transformed into a binary form to alleviate severe multicollinearity problems encountered during the calibration phase.

B. The Equations of the Model

During the calibration phase, an attempt was made to construct 30 empirical equations. However, only 28 equations are presented in the paper. Two equations containing dubious statistical relationships were deleted from the model. Hence, the pictorial representation of the model is depicted in Chart 2.1. This chart contains 95 columns and 30 rows. The columns are identified by the explanatory variable number (X_i) whereas the row denotes the various equations (Q_1 through Q_{30}).

An asterisk (*) in this chart (I) denotes a particular explanatory variable hypothesized to be included in a particular equation of this final model. Thus, cells containing no asterisk (*) denote explanatory variables found to be of a dubious statistical value and as such were not included in the equation(s) of the model.

A cursory examination of this chart will show for example, the outcome Q_i (i.e., PEP - 3rd Grade Reading) is said to be influenced by a set of explanatory variables (denoted by an asterisk in the first row) concerning expenditure (per pupil) on:

o X(11) = total inst./admintr/improvement

o X(13) = teacher salaries

o X(19) = media's instructional salaries

o X(21) = media's equipment

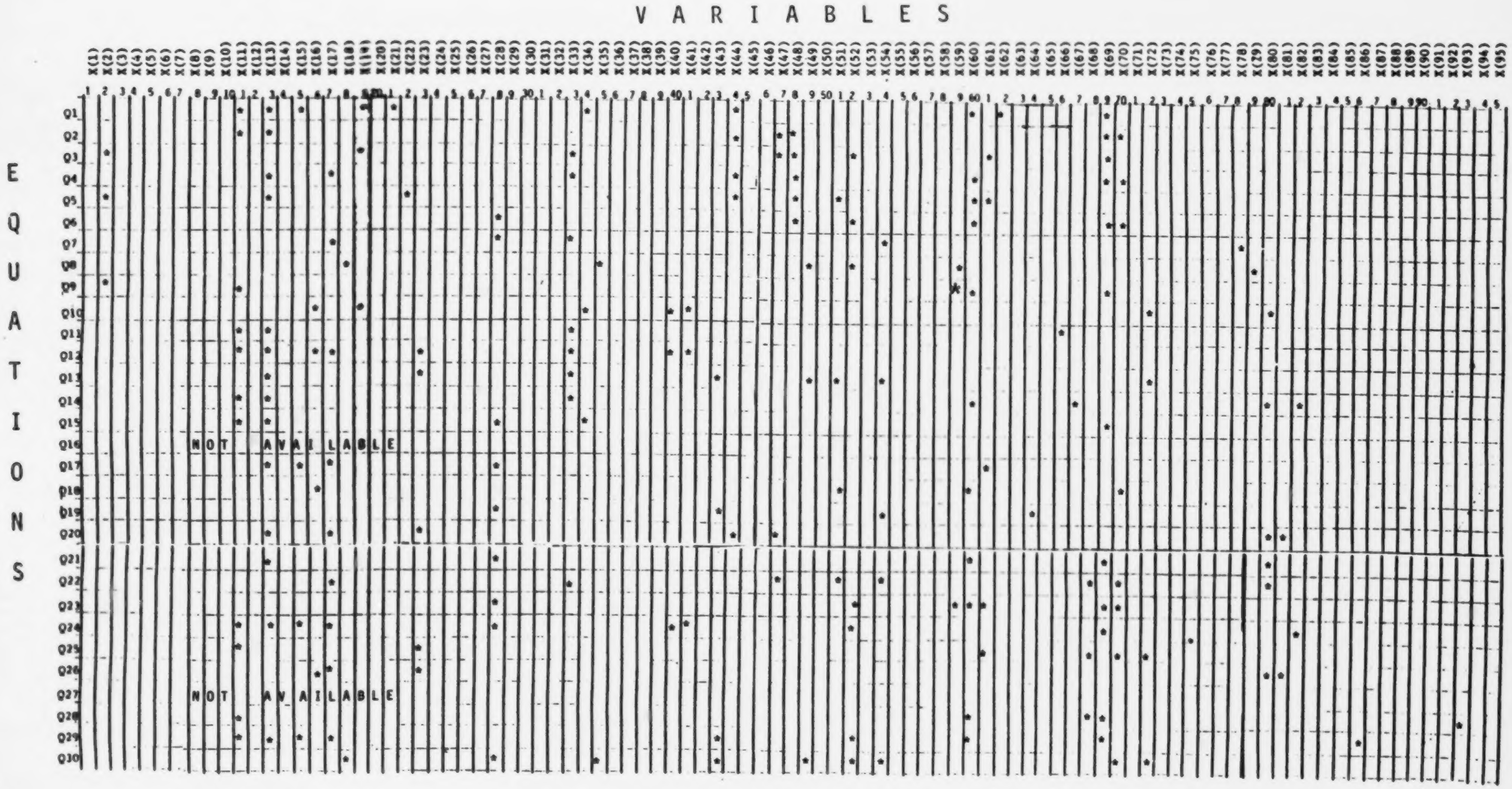
Etc.

On the other hand, the formal structure of 28 equations portraying the statistical ends/means relationships can be found in Table 2.2, at the end of this chapter. Although the equations depicted in Table 2.2 are analogous to that of equation No. 2 (found in Section III) they can be transformed back into a logistic structure as denoted by the theoretical model (i.e. equation No. 1, Section III).

To allow the interested reader to draw inferences regarding the "goodness" of the model, additional statistical measurements regarding these equations are presented in Table 2.2. Specifically, this table denotes the estimated regression coefficients and their respective

Chart 2.1

PICTORIAL REPRESENTATION OF THE LOGISTIC MODEL



explanatory variables, the standard error of these coefficients (SEC), and/or their corresponding "student-t" values, along with the mean of the dependent variables (Q_i), the "standard error of the estimate" (SEE) for each equation, and the sample size used to calibrate each equation. Finally, the R^2 value for each equation is also provided in that table, even though its meaning may be of limited value inasmuch as the dependent variables (Q_i) of this model have been transformed while the explanatory variables are linear in structure. It has been argued that the R^2 is a viable "coefficient of variation" in a situation where both dependent and explanatory variables are linear [Sauerlender 1973].

C. Inferences That Can Be Drawn from the Model

As was anticipated, several inferences can be drawn from the model. For instance, the model seems to confirm the perception that the school districts are "firms" whose mission is to render a "publicly induced collective service" and as such the scholastic outcomes of their "production" efforts are influenced by:

- the mix of their available financial resources;
- non-financial resources and teachers' qualification found in the districts;
- socio-economic attributes of the community they serve which are beyond the district's control; and
- scholastic performance trends.

Also, the results seem to suggest that economic concepts regarding the a)educational production function, b) non-market firm's behavior, and c) biostatistical and econometric techniques can be reconciled into an amalgamated approach. In using such an amalgamated approach, arrays of educational data were reduced to a manageable set of equations, thereby allowing us to gain a better understanding of the technical relationships between the quality of (educational) outcomes produced and the corresponding educational resources used by the districts.

In addition, other inferences which are not intuitively obvious could also be derived from the equations of the model. For instance, the value of the "beta" coefficient associated with a particular explanatory variable denotes the amount of "standard deviation" (SD) change in the dependent variable due to one "standard deviation" change in that explanatory variable [see Schlosselman, 1982]. Alternatively one can apply a formula suggested recently by Petersen (1985) to calculate the change in the probability value of dependent variable (of a logistic equation) resulting from a unit of change in a particular exploratory variable. Finally, one can employ the economic concept of elasticity to estimate the percentage change in the dependent variable due to 1% change in a given explanatory variable. The elasticity for a logistic equation can be derived through the application of an equation suggested by Chiswick (1975);

$$3)\ E = b_i \bar{X}_i \ (1-\bar{P}_i)$$

Where;

E = elasticity
b_i = regression coef.
$\bar{X}_i$ = mean value of explanatory variable X_i
$\bar{P}_i$ = mean value of probability P_i (i.e., mean of Dept. Var. Q_i)

A preliminary elasticity analysis revealed that the several nonfinancial variables have an elasticity value greater than 1.0, whereas the financial variables' elasticity values were found to be 0.3-0.8. The ramification of these findings is that property-poor districts may have to spend money at a rate that is much higher than their desired rate of scholastic achievement.

D. Improvement of the Model

Granted the validity of the conceptual and the empirical models, the calibration of a statistically improved set of logistic equations should be attempted. While the model as a whole seems to be theoretically sound, few equations were found to be statistically inconclusive. This problem has been manifested among other things in terms of a low R^2 value found in selected equations. To enhance the explanatory power of the equations, one can:

- modify some of the variables used to construct the current model; and
- use an alternative calibration technique to estimate the coefficients (parameters) of the equations.

It is suggested therefore, that a set of composite variables be constructed and replace some of the nonfinancial variables (X_{48} through X_{77}) concerning the teachers, socio-economic and community attributes of the districts. Such composite variables can be constructed through the application of a normalization procedure. On the other hand, the possibility of removal of the overhead variables (X_{44} - X_{47}) from the equations of the model, should be explored because as negotiatable items they are not controlled by the district. Moreover, one should explore the possibility that some of the explanatory variables enter the model as nonlinear rather than linear variables. It is also suggested the January RCT exam results (rather than June) be used to construct the dependent variables Q_8 and Q_9. It was brought to our attention rather late in this project (i.e., Sept. 1988) that these RCT tests are traditionally administrated by the state during the month of January. Also, it is postulated that a community net worth variable, rather than the income per return variables (e.g., X_{56}, X_{69}, X_{70}) will enhance the portrayal of the district's socioeconomic condition as was demonstrated by Spottheim/ Libassi and Wilson (1984). Finally, an attempt should be made to recalibrate equations Q_6, Q_{18}, Q_{19}, Q_{23}, and Q_{28} so as to include additional financial variables. It is postulated that such equations will enhance the goal programming solutions found in the next chapter.

In addition to the above suggestions, the application of an alternative calibration technique should be explored as a means to improve the "goodness" of the equations of the model. Therefore, it is suggested that the application of Draper's (1981) "centering" procedure be explored as a tool for estimating the logistic equations' parameters (coefficients). The advantage of this technique lies in its ability to mitigate calibration problems due to:

- multicollinearity found among the data base variables;
- widely differing numerical value of variables (e.g., X_{13} = 1,935; X_{41} = .69; X_{52} = 25,700) used in the same computation [Draper, 1981].

In fact, an exploratory analysis in which the centering procedure was used to recalibrate three of the logistic equations has been successfully executed. In doing so the current rather than the suggested explanatory variables were used. It is postulated therefore, that upon the creation of the suggested variables and the consequent application of the "centering" procedure in conjunction with the modified data base, a "superior" model will be obtained. However, while applying this calibration approach the "outlier" school districts (whose residuals are much greater than the rest of the districts) should be eliminated from the data sample used to calibrate the equations.

V. SUMMARY

In the preceding sections the application of an amalgamated research approach to the problem of effective resource utilization within school districts has been presented. While general economic and research principles were used to construct the model, this endeavor was influenced by the suspicion that the empirical (descriptive) model is likely to be composed of a set of "logistic" equations (see also, Spottheim, June 1982, March 1983). The examination of raw data along with the review of accepted body of theories reinforced this notion. To develop this applied research approach of economic concepts advocated by Fox (1972), Cohn (1975), Cobb and Douglas (1928), Monk (1980), Perloff (1968), Shapiro (1984), Thomas (1977), along with applied research techniques and concepts suggested by Besset (1982), Heim (1972), Cohn & Millman (1975), Kuhns (1972), Spottheim/Libassi/Wilson (1984), Thomas (1962), Wendling (1981) and others have used as the foundation of this research endeavor. The calibration technique was then tempered with newly advocated biostatistical concepts advocated by Cox (1972), Colquhoun (1971), Schlosselman (1985) and others, in order to construct the statewide logistic model, containing 28 logistic equations.

Thus, an effort was made to calibrate 28 logistic equations denoting the relationships between expenditures and pupil performances. In the course of this effort, "cross sectional" (i.e., one year) administrative data (1984-1985) for 200 school districts was collected and analyzed. Consequently, a prototype and this final empirical model were constructed. This final model is said to be "prospective" in nature.

While the model as a whole was found to be theoretically sound, some of its equations were found to be statistically inconclusive. However, this problem, as noted earlier, can be corrected through the modification of selected variables and the application of Draper's (1981) "centering" technique.

In sum, the application of a modified educational production function (portraying the relationships between the quality of scholastic outcomes produced and resources used) along with econometric and biostatistical techniques applied so far, should not be viewed as an esoteric or mysterious process. Rather, this amalgamated approach was devised to extract relevant information from numerical data concerning educational finance. The result of this effort demonstrated that an array of educational data can be reduced into a manageable set of equations. These equations summarized the educational ends and means relationships. The methodology used to construct the model is advantageous because it allows other investigators to replicate and test the model in different settings.

While the equations may be regarded by some as useless or intangible decision-making instruments, inasmuch as they do not deal with classroom instructions [see Barr and Dreeben, 1977], they can be used in conjunction with a goal programming technique to simulate the allocation of resources needed to achieve predetermined and diversed scholastic goals by different types of schools as demonstrated elsewhere (Spottheim and Wilson, 1984). A discussion concerning the application of this resource allocation procedure in this study, is presented in the next chapter (No. 3).

Table 2.2

Edited
11/6/88

THE FINAL LOGISTIC MODEL*

PEP - Reading 3rd Grade

1.

$Q_1 = 2.27$	$- .002\ X_{11}$	$+ .001\ X_{13}$	$+ .005\ X_{15}$	$+ .0078\ X_{19}$	$- .007\ X_{21}$	$+ .011\ X_{34}$	$- .0023\ X_{44}$	$+ .029\ X_{60}$	$- .032\ X_{62}$	$- .248\ X_{69}$
	(SEC =.001)	(.0003)	(.002)	(.002)	(.004)	(.003)	(.0007)	(.011)	(.018)	(.171)
	[t=2.7]	[2.6]	[2.8]	[3.3]	[1.8]	[3.2]	[3.2]	[2.5]	[1.7]	[1.45]

$\bar{Q}_1 = 2.7$; SEE = .715; $R^2 = .386$; Sample size = 159 School District

PEP - Math 3rd Grade

2.

$Q_2 = 4.83$	$- .0017\ X_{11}$	$+ .001\ X_{13}$	$- .001\ X_{44}$	$- .00075\ X_{47}$	$- .0002\ X_{48}$	$- .65\ X_{69}$	$+ .385\ X_{70}$
	(.001)	(.0004)	(.0008)	(.0004)	(.00008)	(.195)	(.227)
	[1.48]	[2.0]	[1.6]	[1.65]	[2.50]	[3.35]	[1.7]

$\bar{Q}_2 = 3.0$; SEE = .793; $R^2 = .217$; Sample size = 147 S.D.

PEP - Writing 5th Grade

3.

$Q_3 = 4.67$	$+ .005\ X_{2}$	$- .005\ X_{19}$	$+ .010\ X_{33}$	$- .0012\ X_{47}$	$- .001\ X_{48}$	$+ .065\ X_{52}$	$- .12\ X_{61}$	$- .55\ X_{69}$
	[1.49]	[1.80]	[1.50]	[2.80]	[2.4]	[1.53]	[2.2]	[2.6]

$\bar{Q}_3 = 2.93$; SEE = .97; $R^2 = .176$; Sample size = 159 S.D.

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*Whereas the variable number in Table I was indicated in ( ), it is denoted in this table as a subscript.

Table 2.2 (cont'd.)

PEP - Reading 6th Grade

4. $Q_4 = 2.67 + .0008\ X_{13} + .0016\ X_{17} + .010\ X_{33} - .002\ X_{44} - .0001\ X_{48} + .0338\ X_{60} - .408\ X_{69} + .345\ X_{70}$

(.0004) (.0009) (.005) (.0005) (.00007) (.011) (.176) (.205)

[2.0] [1.86] [1.9] [3.75] [2.27] [2.90] [2.3] [1.68]

$\bar{Q}_4 = 2.59$; SEE = .739; $R^2 = .31$; Sample size = 158 S.D.

PEP - Math 6th Grade

5) $Q_5 = 3.03 + .009\ X_2 + .0008\ X_{13} - .008\ X_{22} - .002\ X_{44} - .0012\ X_{48} + .0151\ X_{51} + .027\ X_{60} - .098\ X_{61}$

(.003) (.0004) (.005) (.0006) (.0004) (.010) (.014) (.049)

[2.60] [1.9] [1.75] [3.06] [3.10] [1.48] [1.95] [1.98]

$\bar{Q}_5 = 2.79$; SEE = .836; $R^2 = .30$; Sample size = 158 S.D.

PCT - Reading 8th Grade

6. $Q_6 = 3.1 - .005\ X_{28} - .0002\ X_{48} + .053\ X_{52} + .024\ X_{60} - .587\ X_{69} + .682\ X_{70}$

[2.7] [2.5] [1.26] [1.77] [2.83] [3.1]

$\bar{Q}_6 = 3.24$; SEE = .92; $R^2 = .20$; Sample size = 157 S.D.

RCT - Math

7. $Q_7 = 1.47 + .0017\ X_{17} - .0068\ X_{28} + .010\ X_{33} + .00004\ X_{54} + .52\ X_{78}$

(.001) (.001) (.006) (.00002) (.19)

[1.50] [4.24] [1.72] [1.68] [2.65]

$\bar{Q}_7 = 1.59$; SEE = .95; $R^2 = .237$; Sample size 161 S.D.

Table 2.2 (cont'd)

RCT - Reading

8. $Q_8 = 3.76 - .0005\ X_{18} + .012\ X_{35} - .002\ X_{49} - .102\ X_{52} - 102\ X_{59} + .474\ X_{79}$

(.0002) (.004) (.0001) (.0052) (.015) (.218)

[2.0] [3.0] [2.2] [1.94] [1.65] [2.17]

$\bar{Q}_8 = 2.41$; SEE = .61; $R^2 = .60$; Sample size = 150 S.D.

RCT - Writing

9. $Q_9 = 1.91 + .009\ X_2 - .0028\ X_{11} - .216\ X_{59} + .247\ X_{60} - .711\ X_{69}$

(.004) (.001) (.060) (.068) (.28)

[1.98] [2.12] [3.61] [3.6] [2.5]

$\bar{Q}_9$ = NA; SEE = 1.33; $R^2 = .145$; Sample size = 150 S.D.

REG - Bookeeping

10. $Q_{10} = 2.34 - .009\ X_{16} - .0067\ X_{19} + .0065\ X_{34} - .038\ X_{40} + .167\ X_{41} - 1.05\ X_{72} + .48\ X_{80}$

[2.1] [1.8] [1.04] [2.53] [2.29] [4.3] [1.98]

$\bar{Q}_{10}$ = NA; SEE 1.2; $R^2 = .28$; Sample Size = 119 S.D.

REG - Business Law

11. $Q_{11} = -.387 - .005\ X_{11} + .0007\ X_{13} + .014\ X_{33} + .10\ X_{66}$

[2.6] [1.6] [1.44] [1.76]

$\bar{Q}_{11} = 2.06$; SEE 1.31; $R^2 = .09$; Sample Size = 122 S.D.

Table 2.2 (cont'd)

REG - Business Math

12. $Q_{12} = 1.5 - .004\ x_{11} + .0012\ x_{13} - .010\ X_{16} + .0022\ X_{17} + .0072\ X_{23} - .034\ X_{33} + .042\ X_{40} + .197\ X_{41}$

[1.77] [2.24] [2.0] [1.16] [2.15] [2.98] [2.07] [3.74]

$\bar{Q}_{12} = 2.23$; SEE = 1.4; $R^2 = .253$; Sample Size = 118 S.D.

REG - English

13. $Q_{13} = -\ .153 - .0016\ X_{13} + .002\ X_{23} - .009\ X_{33} + .022\ X_{43} - .0001\ X_{49} + .028\ X_{51} + .00017\ X_{54} - .463\ X_{72}$; (cal. 8/7/88)

[3.27] [1.32] [1.65] [3.1] [2.07] [2.5] [3.6] [2.7]

$\bar{Q}_{13} = 2.43$; SEE = .89; $R^2 = .23$; Sample Size = 158 S.D.

REG - French

14. $Q_{14} = 1.02 - .003\ X_{11} + .0005\ X_{13} - .010\ X_{33} + .043\ X_{60} + .056\ X_{67} + .418\ X_{80} + .27\ X_{82}$

[2.7] [1.78] [1.6] [2.65] [1.65] [2.1] [1.55]

$\bar{Q}_{14} = 3.5$; SEE = 1.07; $R^2 = .16$; Sample size = 154 S.D.

REG - German

15. $Q_{15} = 9.47 - .006\ X_{11} - .0013\ X_{13} + .009\ X_{28} - .150\ X_{34} - 1.35\ X_{69}$

[2.24] [1.76] [2.17] [1.6] [2.33]

$\bar{Q}_{15} = 3.5$; SEE = 1.37; $R^2 = .21$; Sample size = 65 S.D.

Table 2.2 (cont'd)

REG - Italian

16. Q_{16} = NOT AVAILABLE

REG - Latin

17. $Q_{17} = 9.18 - .0015\ X_{13} + .0105\ X_{15} - .0067\ X_{17} + .0072\ X_{28} - .242\ X_{61}$

(.0006) (.0006) (.003) (.0042) (.12)

[2.3] [2.3] [2.07] [1.71] [1.9]

$\bar{Q}_{17} = 3.4$; SEE = 1.28; $R^2 = .237$; Sample Size = 55 S.D.

REG - Spanish

18. $Q_{18} = 2.7 + .004\ X_{16} - .18\ X_{51} + .044\ X_{60} + .42\ X_{70}$

[1.23] [1.53] [2.45] [1.48]

$\bar{Q}_{18}$ = N/A; SEE = 1.15; $R^2 = .112$; Sample Size = 150 S.D.

REG - Math 9

19. $Q_{19} = 2.035 - .0086\ X_{28} - .023\ X_{43} + .00016\ X_{54} - .11\ X_{64}$

[3.15] [1.07] [3.11] [2.1]

$\bar{Q}_{19} = 2.035$; SEE = 1.19; $R^2 = .163$; Sample Size = 70 S.D.

Table 2.2 (cont'd)

REG - Math 10

20. $Q_{20} = -.17 + .0017\ X_{13} - .004\ X_{17} + .0032\ X_{23} - .003\ X_{44} + .0015\ X_{47} + .562\ X_{80} + .518\ X_{81}$

[3.0] [2.3] [1.42] [3.0] [2.2] [2.6] [2.9]

$\bar{Q}_{20} = 1.6$; SEE = .89; $R^2 = .33$; Sample Size = 100 S.D.

REG - Math 11

21. $Q_{21} = .916 + .001\ X_{13} - .0035\ X_{28} - .03\ X_{60} - .479\ X_{69} + .240\ X_{80}$; (cal. 8/8/88)

(.003) (.001) (.013) (.21) (.16)

[3.2] [2.0] [2.2] [2.26] [1.45]

$\bar{Q}_{21} = 1.58$; SEE = .80; $R^2 = .216$; Sample Size = 119 S.D.

REG - Seq. Math I

22. $Q_{22} = 1.09 - .042\ X_{17} - .0088\ X_{33} + .001\ X_{47} + .014\ X_{51} + .00004\ X_{54} - .086\ X_{68} + .79\ X_{70} + .74\ X_{80}$

(.001) (.005) (.0005) (.009) (.00002) (.027) (.24) (.17)

[3.7] [1.54] [2.1] [1.5] [1.98] [3.15] [3.3] [4.3]

$\bar{Q}_{22} = 1.9$; SEE = .83; $R^2 = .48$; Sample Size = 115 S.D.

REG - Seq. Math II

23. $Q_{23} = 1.4 - .007\ X_{28} + .152\ X_{52} - .130\ X_{59} + .162\ X_{60} - .076\ X_{61} - 1.08\ X_{69} + .869\ X_{70}$; (Cal. 7/23)

(.002) (.059) (.062) (.68) (.034) (.342) (.30)

[3.4] [2.56] [2.11] [2.38] [2.26] [3.18] [2.89]

$\bar{Q}_{23} = 2.0$: SEE = .92; $R^2 = .35$; Sample Size = 81 S.D.

Table 2.2 (cont'd)

REG - Seq. Math III

24. $Q_{24} = 1.05 + .004\ X_{11} - .0011\ X_{13} + .006\ X_{15} - .0027\ X_{17} - .0046\ X_{28} + .023\ X_{40} - .087\ X_{41} + .140\ X_{52} - .854\ X_{69} + .70\ X_{82}$

[2.43] [1.88] [1.84] [1.95] [1.5] [1.66] [2.15] [2.2] [2.2] [3.0]

$\bar{Q}_{24} = 1.97$; SEE = .897; $R^2 = .42$; Sample Size = 65 S.D.

REG - Biology

25. $Q_{25} = .94 - .002\ X_{11} + .0015\ X_{23} + .06\ X_{61} + .037\ X_{68} + .715\ X_{70} - .56\ X_{72}$

[2.8] [1.1] [2.3] [1.9] [3.7]

$\bar{Q}_{25} = 2.19$; SEE = .85; $R^2 = .21$; Sample Size = 161 S.D.

REG - Chemistry

26. $Q_{26} = .874 + .005\ X_{16} - .0024\ X_{17} + .003\ X_{23} + .40\ X_{80} + .41\ X_{81}$

(.002) (.001) (.0014) (.165) (.163)

[2.27] [2.1] [2.28] [2.42] [2.52]

$\bar{Q}_{26} = 2.11$; SEE = .96; $R^2 = .134$; Sample Size = 162 S.D.

REG - Earth Science

27. NOT AVAILABLE

Table 2.2 (cont'd)

REG - Physics

28. $Q_{28} = 1.44 - .0045 X_{11} + .039 X_{60} + .070 X_{68} - 1.05 X_{69} + .714 X_{93}$;(Cal. 7/24/88)

(.001) (.015) (.027) (.24) (.235)

[4.1] [2.58] [2.5] [4.4] [3.0]

$\bar{Q}_{28} = 2.44$; SEE = 1.126; $R^2 = .20$; Sample Size = 157 S.D.

REG - Soc. Science

29. $Q_{29} = 3.42 - .0023 X_{11} + .0004 X_{13} - .0023 X_{15} - .0023 X_{17} + .139 X_{43} - .114 X_{52} + .0288 X_{60} - .349 X_{69} + .63 X_{86}$

[2.5] [1.66] [1.11] [2.53] [2.3] [3.16] [2.52] [1.91] [4.4]

$\bar{Q}_{29} = 1.878$; SEE = .755; $R^2 = .32$; Sample Size = 151 S.D.

Dropout

30. $Q_{30} = - 2.49 + .00054 X_{18} + .0023 X_{28} - .004 X_{35} - .009 X_{43} + .02 X_{49} - .048 X_{52} - .0001 X_{54} -.96 X_{70} + .50 X_{72}$

[1.77] [1.66] [1.88] [1.81] [3.46] [1.51] [3.62] [5.0] [4.0]

$\bar{Q}_{30} = - 4.08$; SEE = .634; $R^2 = .57$; Sample Size = 157 S.D.

Legend

figures in ( ) below the coef. denotes the Standard Error of the Coefficient (SEC)
bracketed [ ] figures depict the "student 't'" statistics
$\bar{Q}_i$ = Mean Value of Q_i (dept. var. i)

SEC = Standard Error of the Coef.

SEE = Standard Error of the Estimate

R^2 = Coefficient of Variation

3

FINANCIAL RESOURCE ALLOCATION PROCEDURE FOR ACHIEVING EDUCATIONAL TARGETS: A GOAL PROGRAMMING APPROACH

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CHAPTER THREE

FINANCIAL RESOURCE ALLOCATION PROCEDURE FOR ACHIEVING EDUCATIONAL TARGETS: A GOAL PROGRAMMING APPROACH*

I. INTRODUCTION

In 1983 the public education sector had spent 11.6 billion dollars on the education of 2.66 million pupils enrolled in 735 public school districts of the State of New York [see Financial Data for School Districts, June 1983].** During the said year the total expenditures by local government of the State of New York amounted to 36.3 billion dollars [Comptroller's Special Report on Municipal Affairs - 1983], whereas the total state personal income was $231.1 billion [New York State Statistical Yearbook 1985-1986, Table E-4]. Thus, about 5% of the total personal income originated in the public education sector and 31.9% of the local government expenditure was devoted to support the state obligation of providing free education to its children.

While the provision of educational services to the children can be justified in principle, on legal grounds, the accountability of expenditures for such services can be enhanced through the utilization of management science techniques. However, it had become evident in an earlier project that the New York State educational systems barely examined the problem of efficacious utilization of financial resources [see Spottheim et al., 1984]. The lack of attention to this problem can be attributed to a prevailing view threaded through various governmental reports.

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**Sources cited are listed at the end of this report.

Although the expenditure of monies is being audited by the State of New York, the prevailing notion is that accounting practices do not serve to evaluate the effectiveness of these expenditures [see Wohlfred, 1970]. Apparently this notion is shared by a recently created commission in New York State whose recommendations barely address the efficacious utilization of financial resources [Rubin, 1982], and the same can be said about the recommendations of national commissions. The collective view of these commissions is that the education sector can be more effective through the implementation of stiffer educational standards and graduation requirements [see N.Y. Times, Nov. 13, 1983; Aug. 24, 1987; Wall Street Journal, April 26, 1984].

This view, however, can be challenged because economics and management science literature contains accepted theories and quantitative techniques that can be applied to the efficacious utilization of resource problems. The central theme of this body of literature is that the "need" to spend more money on specific functions is unwarranted, unless it can be shown that such functions are more effective than others [see Cohn/Millman, 1975; Fox, 1972; Lee, 1979]. Since the content of this chapter is an extension of this body of literature, it focuses on the application of economics and operations research (i.e., management science) methods to the problems of the effective allocation of resources not addressed by the various commissions.

A. The Problem

The egalitarian educational philosophy in the State of New York and the emerging consensus regarding the need to invest in human capital on one hand, along with the limited availability of resources on the other hand, have created a situation in which the school districts are facing multiple and conflicting administrative goals. Moreover, the fact that the school districts are said to be enterprises operating in a nonmarket environment has exacerbated the problem of resource allocation within school districts.

Although conventional management practices are well established in public education sectors, they cannot be applied to estimate the required resources needed to ascertain the multiple and sometime conflicting educational goals. To resolve this situation one must rely on proven resource allocation techniques advocated in educational economics and management science literature

B. The Approach

While the logistic model (presented in Chapter Two) depicts certain input-outcome relationships of the educational process, the equations of this model cannot be used alone to ascertain resource allocation solutions for firms whose "production" goals are multiple and sometimes conflicting. Thus, should the educational decision makers agree that certain educational targets (or goals) are more important than others, then a multiobjective resource allocation method (like the goal programming technique) could be used in conjunction with the said model for the purpose of determining the appropriate mix of financial resources (inputs) needed to ascertain these prioritized targets.

C. The Theme and Structure of This Chapter

The premise behind this approach is that the financial resource mix (by functions) can be adjusted so as to approach the "production possibility frontier" with respect to the predetermined and prioritized scholastic targets of various types of schools. Hence, the composition of financial resources needed to realize such goals (or targets) were derived through the application of a goal programming technique as was advocated by Ignizio (1982) in conjunction with the aforementioned logistic model. Such an amalgamation of techniques is a common research practice in the management science field of inquiry [see Fox, 1972; Banker et al., 1986; Spottheim/Wilson, 1986-1988]. Fox (1972) has suggested that this approach can be used to allocate resources within school districts, while Cohn (1975), Morgan (1977), and Spottheim/Libassi/Wilson (1984) have applied this approach to allocate resources within selected school districts located in the Long Island region.

It should be noted however, the amalgamated approach presented in this chapter is not a direct extension of the previously mentioned studies inasmuch as it portrays the relationships between the quality (expressed as the probability of attaining a preemptive and practical level of educational output/outcome) produced and the required financial resources needed to achieve the scholastic targets. On the other hand, earlier educational economics studies by Cohn (1975), Morgan (1977), and others, dealt merely with the quantity of educational outputs produced and the corresponding resources required.

To demonstrate the applicability of this approach (with respect to the predicament mentioned earlier in Chapter I), a few scenarios were formulated and solutions for various types of school districts (i.e., low, high income) were simulated. Thus, the remainder of this paper is structured as follows: a survey of goal programming concepts and applications is presented in Section II whereas the educational goal programming model is briefly discussed in Section III. The solutions for various scenarios are presented in Section IV. Suggested improvements of this allocation procedure are presented in Section V. A summary of this endeavor can be found in Section VI.

II. GOAL PROGRAMMING CONCEPTS AND APPLICATION

It has been argued in the management science literature that there is no single goal which is ubiquitous to all organizations: rather organizations have multiple and conflicting goals. Because of this situation, organizational decision makers continuously face a predicament of attaining a set of goals to the fullest possible extent in an environment of conflicting interests, limited resources, incomplete information, and knowledge concerning the complexity of their operational environment [Lee, 1972]. Consequently, scholars such as Charnes and Cooper (1961) have developed the "goal programming" technique to handle such decision-making environments [see Charnes and Cooper, cited in Lee, 1972, p. 35]. Traditionally this technique has been used to:

- determine the amount of resources needed to realize a set of prioritized production goals;
- explore the attainability of these goals; and
- ascertain optimal solutions under various administrative scenarios [Lee, 1979].

Since its development the technique was used in a variety of fields to determine solutions for a pre-specified set of complex and conflicting objectives of various types of organizations. In other words, goal programming, as noted by Lee (cited in Morgan, 1977), was used for the attainment of a "satisficing" solution which is subject to varying inputs and prioritized goals. This method could handle variables measured in terms of non-homogeneous units (i.e., money, pupils, teachers, etc.); therefore, it was widely applied to the resource allocation problems of nonprofit and "nonmarket" institutions in general, and educational systems in particular [Lee, 1972; Morgan, 1977; Cohn et al., 1980]. In this paper, the varying input requirements were established by a recently developed production function model which is discussed in Chapter Two [Spottheim/Libassi, Sept., 1988; also see Spottheim/Wilson/Libassi, March 1984]. The prioritized educational goals, on the other hand, were established through consultation with educators and administrators.

A. Application of Goal Programming

Since its inception by Charnes and Cooper (1961), the goal programming technique was applied to a host of problems in various areas. Ijiri (1965) has used this technique for accounting control, whereas Lee (1972) applied this technique to problems concerning production planning, financial decisions and academic planning. Kendall and Lee (1980), on the other hand, have applied this technique to simulate medical care policies, while Bres and others (1980) have used it in military manpower planning. Sharpe (1970) has used this technique in conjunction with descriptive statistics to carry out a portfolio analysis. The rationale behind his study is that investment decisions can be simulated while using information concerning expected return and standard deviation of the expected returns [Sharpe cited in Goicoechea, et al., 1982].

Fox (1972) has suggested that this technique can be used to simulate higher education problems, whereas Cohn and Millman (1975) have argued that this technique can be used in conjunction with a regression model (portraying input/output relationships) to simulate the attainability of predetermined goals of a Pennsylvania education system. Morgan (1977), Cohn and Morgan (1977), and Cohn et al (1980) have demonstrated that such an amalgamated approach can be applied to resource allocation problems within school districts. Spottheim/Wilson (1984), on the other hand, have used linear goal programming techniques in conjunction with a "logistic" model to estimate the financial resources needed to realize a set of predetermined and prioritized educational targets. Spottheim and Wilson (1986-1988) have also applied the goal programming technique in conjunction with the queueing theory while analyzing the productivity and performance problems faced by social service delivery organizations. Finally, Bessent et al (1982) have recently applied a related mathematical programming approach, Data Envelopment Analysis (DEA), to assess the "productivity" of schools located in Houston, Texas, and Sherman (1981) used the same program to measure the efficiency of hospital operations [see Sherman (1981) cited in Bessent et al., 1982].

B. An Illustrative Goal Programming Formulation

The Goal Programming technique, as was noted earlier, is applicable in a situation where decisions are characterized by multiple objectives. The technique provides a solution which minimizes the sum of deviations from the prescribed set of preemptive target values (goals). Conventionally, goals are defined by the field of management science as "desired" outcomes which are operational (i.e., measurable). To simulate the attainability of these goals through the application of an amalgamation of goal programming and econometric techniques, specific information concerning the system is required:

- formulas (or models) denoting the technical relationships between resources and outputs of the system in question;
- values of target (or goal) variables for each objective;
- upper and lower bounds of input (resource) variables;
- prioritization of objectives and their corresponding weights within priority classes.

Such information is then incorporated into the goal programming statement and upon execution of the technique, the following information is obtained:

- estimated value of the output (target) variables that could be achieved;
- estimated value of corresponding resources (inputs) needed to produce the estimated outputs (or targets);
- indices denoting the achievement functions.

The concepts of the foregoing discussion are expressed mathematically below. Characteristic of this expression is that it contains a formal (i.e., mathematical) notation concerning objective functions, constraints, and deviational variables. Notice that (unlike linear programming) the objective function in this technique is always specified as a minimization statement. The formulation of a problem could be functionally stated in Ignizio (1982) goal programming notation:

1. Minimize; $\bar{a} = [g_1 (d^+, d^-), \ldots, g_n (d^+, d^-)]$

   Subject to the following conditions;

2. $f_i (\bar{F}, \bar{C}) \quad -d_i^+ + d_i^- = G_i, \; i = 1, 2, \ldots, n$

In this study for instance, the outcomes, $Q_i = f_i$; $i = 1,2,\ldots 28$

Where,

d_i^+ = a "positive" deviational variable associated with the ith goal. This variable designates the amount by which the ith goal is exceeded.

d_i^- = a "negative" deviational variable associated with the ith goal. This variable designates the amount by which f_i is less than the ith goal.

d^+ = a vector with elements d_i^+

d^- = a vector with elements d_i^-

$g_i \; (d^+, d^-)$ = a linear relation of deviational variables evaluated at priority level i, where the g_i is a functional notation.

$\overline{F}$ = a vector with elements F_i - - i.e., in our case it could denote (financial) variables.

$\overline{C}$ = a vector with elements C_i - - i.e., community variables beyond the control of the district.

$\overline{Q}$ = a vector with elements Q_i - - i.e., output (or outcome) variables (in our instance $Q_i = f_i$, $i = 1, 2 \ldots, 28$).

The assumptions and restrictions of the model imply that there cannot be a negative resource (input) and the "deviational variables" (d_i^-, d_i^+) cannot be negative. Thus, the notation d_i^-, for example, refers to an "underachievement" variable when it is desired that goal i be equalled or exceeded, whose magnitude is not less that zero. Symbolically this statement can be expressed as follows:

$$F_1, F_2, \ldots\ldots, F_n \geq 0$$
$$d_1^+, d_1^-, d_2^+, d_2^-, \ldots\ldots, d_n^+ \geq 0$$

Goal programming techniques can handle complex and conflicting objectives, (i.e., targets or goals), whereas a linear programming technique requires a single objective function. The former method, however, presupposes that school administrators, for example, can rank specific targets (goals), hierarchically, thereby allowing this technique to search for a "satisficing" (rather than optimizing) solution concerning the mix of required resources to ascertain the prioritized goals or targets. If an exact financial resource (inputs) mix is impossible to obtain, this method would provide a solution which minimizes the sum of the deviations from the prespecified educational targets. It would also determine the amount and mix of resources needed to realize these prioritized goals. Finally, should the priority of the educational targets be reordered, the technique would provide information concerning the resources needed to realize such targets.

III. A GOAL PROGRAMMING MODEL FOR PUBLIC SCHOOL SYSTEMS

The financial resource allocation procedure presented in this chapter was developed through a fruitful rapproachement of the logistic model developed by Spottheim/Libassi (Sept. 1988), as presented earlier in Chapter Two, and the goal programming technique. In other words, the estimated coefficients of this model were used as the parameters of the goal programming model. The variables used to construct this goal programming model are displayed in Table 3.1. Since only twenty of the 47 financial variables (X_i) entered into one or more of the logistic equations, these variables were renamed as Y_i (financial variables), (where $i = 1,2,\ldots,20$). Hence, Table 3.1 contains both the original variable code (X_i) and the renamed (Y_i) variable code. The same holds for the outcome variables. Therefore, the original logistic outcome variables are denoted by the code Q_i, whereas the redefined variables are denoted by Q_i^*. Notice that the nonfinancial variables (X_{48} - X_{93}) listed in Table 3.1 have no corresponding goal programming code. Since these variables were transferred to the right hand side of the goal programming tableau and as such, they were not manipulated by this model.

Recall that the logistic model was calibrated while using a particular set of New York State school districts; hence, the model captures in essence the "idealized" relationships between educational expenditures and outcomes of an "abstract" district. Therefore, the application of the goal programming model in conjunction with the logistic model, is a useful tool for simulating challenges faced by the school district in general, and the attainment of educational goals with

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TABLE 3.1

LIST OF EXPLANATORY VARIABLES OF THE GOAL PROGRAMMING MODEL

I. FINANCIAL EXPENDITURE DATA (SCH. A4 DATA) PER PUPIL

Logistic Var. No.	Goal Prog. Var. Code	Definition
A. Chief School Administration Office		
X(1)		Instructional Chief School Adm. (Per Total Enrollment)
*X(2)	Y (1)	Total Chief School Adm.
B. Instruction, Administ. & Improv.		
X(3)		Instructional Salaries
X(4)		Non-Instruct. Salaries
X(5)		Equipment/Supply
X(6)		Contractual + BOCES
X(7)		Total Curriculum Develop.
X(8)		Total Supervision
X(9)		Total Research/Education/Plan.
X(10)		Total Training
*X(11)	Y (2)	Total Instr./Administ./Improv.
C. Instructional Teaching		
X(12)		Teachers Salaries K-6
X(13)	Y (3)	Teachers Salaries Total
X(14)		Substitute Teacher Salaries
X(15)	Y (4)	Non-Instructional Salaries
X(16)	Y (5)	Equipment/Supply/Text Books
X(17)	Y (6)	BOCES/Contractual/Tuition
*X(18)	Y (7)	Total Instructional Teaching
D. Instructional Media		
X(19)	Y (8)	Instructional Salaries
X(20)		Non-Instructional Salaries
X(21)	Y (9)	Equipment/Supply
X(22)	Y (10)	BOCES/Contractual
*X(23)	Y (11)	Total Instructional Media

Variables prefixed by "" are summation (financial) variables.

Table 3.1 (Con't.)

Logistic Var. No.	Goal Prog. Var. Code	Definition
E. Pupil Services (Guidance/Health/Psych./Soc. Work)		
X(24)		Instructional Salaries
X(25)		Non-Instructional Salaries
X(26)		Equipment/Supply
X(27)		BOCES/Contractual
*X(28)	Y (12)	Total Pupil Services
F. Pupil Services (Cocurricular/Interscholastic Athletic)		
X(29)		Instructional Salaries
X(30)		Non-Instructional Salaries
X(31)		Equipment/Supply
X(32)		BOCES Serv./Contractual
*X(33)	Y (13)	Total Cocurricular
*X(34)	Y (14)	Total Interscholastic Athletic
*X(35)	Y (15)	Total Cocurric./Athletic
G. Community Service & Recreation		
X(36)		Instructional Salaries
X(37)		Non-Instructional Salaries
X(38)		Equipment/Supply
X(39)		BOCES/Contractual
X(40)	Y (16)	Total Community/Recr.
X(41)	Y (17)	Total Youth Program
X(42)		Total Civic Activities
*X(43)	Y (18)	Total Commun./Youth/Civic
H. Other Overhead Exp.		
*X(44)	Y (19)	Total Emply. Benefit
X(45)		Total Operation & Maint.
X(46)		Total Bus Transportation
*X(47)	Y (20)	Sum of [X(45) + X(46)]
II. NONFINANCIAL VARIABLES		
X(48)		K-6 Enrollments (a size variable)
X(49)		7-12 Enrollments " " "
X(50)		Total Enrollments
X(51)		Sq. Ft. of Classroom per Pupil
X(52)		Av. Teacher Qualifications Index
X(53)		Av. Nonteaching Prof. Qualifications
X(54)		Av. Teachers' Salary
X(55)		No. of Nonteaching Professionals
X(56)		Income per Return (a wealth measurement)
X(57)		No. of Tax Returns

Table 3.1 (Con't.)

Logistic Var. No.	Goal Prog. Var. Code	Definition
X(58)		Income per Pupil
X(59)		No. of Books in School Library
X(60)		No. of Titles in School Library
X(61)		Pupils/Teachers Ratio
X(62)		Avg. Class Size Common Branch (Elem.)
X(63)		" " " Grade 8 English & Soc. Sci.
X(64)		" " " " 8 Math & Sci.
X(65)		" " " " 8 (All subjects)
X(66)		" " " " 10 (All subjects)
X(67)		" " " " 10 English & Social Sci.
X(68)		" " " " 10 Math & Science
X(69)		Dummy (Binary) Income Var. A
X(70)		" " " " Var. B
X(71)		Socio-Economic Indicator
X(72)		Binary Socio Eco. Indicator
X(73)		Pupil Support Staff Ratio
X(78)		Math Grade 6 (Binary - Trend Variable)
X(79)		Reading Grade 8 " " "
X(80)		RCT-Math " " "
X(81)		RCT-Reading " " "
X(82)		RCT-Writing " " "
X(86)		REG-Comp. English " " "
X(93)		REG-Math 10 " " "

III. EDUCATIONAL ACHIEVEMENT VARIABLES

A. PEP Exams

Q (1)	Q(1)*	PEP-Reading Grade 3 above SRP (State Reference Point)
Q (2)	Q(2)*	PEP-Math " " "
Q (3)	Q(3)*	PEP-Writing Grade 5 " "
Q (4)	Q(4)*	PEP-Reading Grade 6 " "
Q (5)	Q(5)*	PEP-Math Grade 6 " "

B. PCT Test

Q (6)	Q(6)*	PCT-Reading Grade 8 " "

C. RCT Tests

Q (7)	Q(7)*	RCT-Math- Passed (June test only)
Q (8)	Q(8)*	RCT-Reading " " " "
Q (9)	Q(9)*	RCT-Writing " " " "

Table 3.1 (Con't.)

Logistic Var. No.	Goal Prog. Var. Code	Definition	
D. **Regents Business Tests**			
Q (10)	Q(10)*	REG-Bookkeeping	(June test only)
Q (11)	Q(11)*	REG-Business Law	" " "
Q (12)	Q(12)*	REG-Business Mat	" " "
E. **Regents Languages**			
Q (13)	Q(13)*	REG-Comp. English	" " "
Q (14)	Q(14)*	REG=Comp. French	" " "
Q (15)	Q(15)*	REG-Comp. German	" " "
Q (16)		REG-Comp. Italian	" " "
Q (17)	Q(16)*	REG-Comp. Latin	" " "
Q (18)	Q(17)*	REG-Comp. Spanish	" " "
F. **Regents Math**			
Q (19)	Q(18)*	REG-Math 9	" " "
Q (20)	Q(19)*	REG-Math 10	" " "
Q (21)	Q(20)*	REG-Math 11	" " "
Q (22)	Q(21)*	REG-Seq. Math I	" " "
Q (23)	Q(22)*	REG-Seq. Math II	" " "
Q (24)	Q(23)*	REG-Seq. Math III	" " "
G. **Regents Sciences/Social Sci./Dropout**			
Q (25)	Q(24)*	REG-Biology	" " "
Q (26)	Q(25)*	REG-Chemistry	" " "
Q (27)		REG-Earth Science	" " "
Q (28)	Q(26)*	REG-Physics	" " "
Q (29)	Q(27)*	REG-Comp. Soc. Stud.	" " "
Q (30)	Q(28)*	Dropout	

Legend

*X(i) = Summation variable

Y(i) = Goal programming financial variable code

Q(i)* = Goal programming scholastic achievement code a discrete set of fixed financial resources, in particular.

A. Educational Resources Allocation Process- A Conceptual Overview

Traditionally, this resource allocation (or simulation) procedure is executed without modifying the existing administrative structure and the decision processes. Therefore, "measurements" which summarize the prevailing educational reality must be identified, quantitatively. Specifically, goal programming model entails the execution of the following steps:

- estimation of the quantitative relationships between educational means and ends;
- specification of prioritized educational targets (ends) of various types of districts as perceived by educational decision-makers;
- determination of achievable level of goals and corresponding resources through simulation.

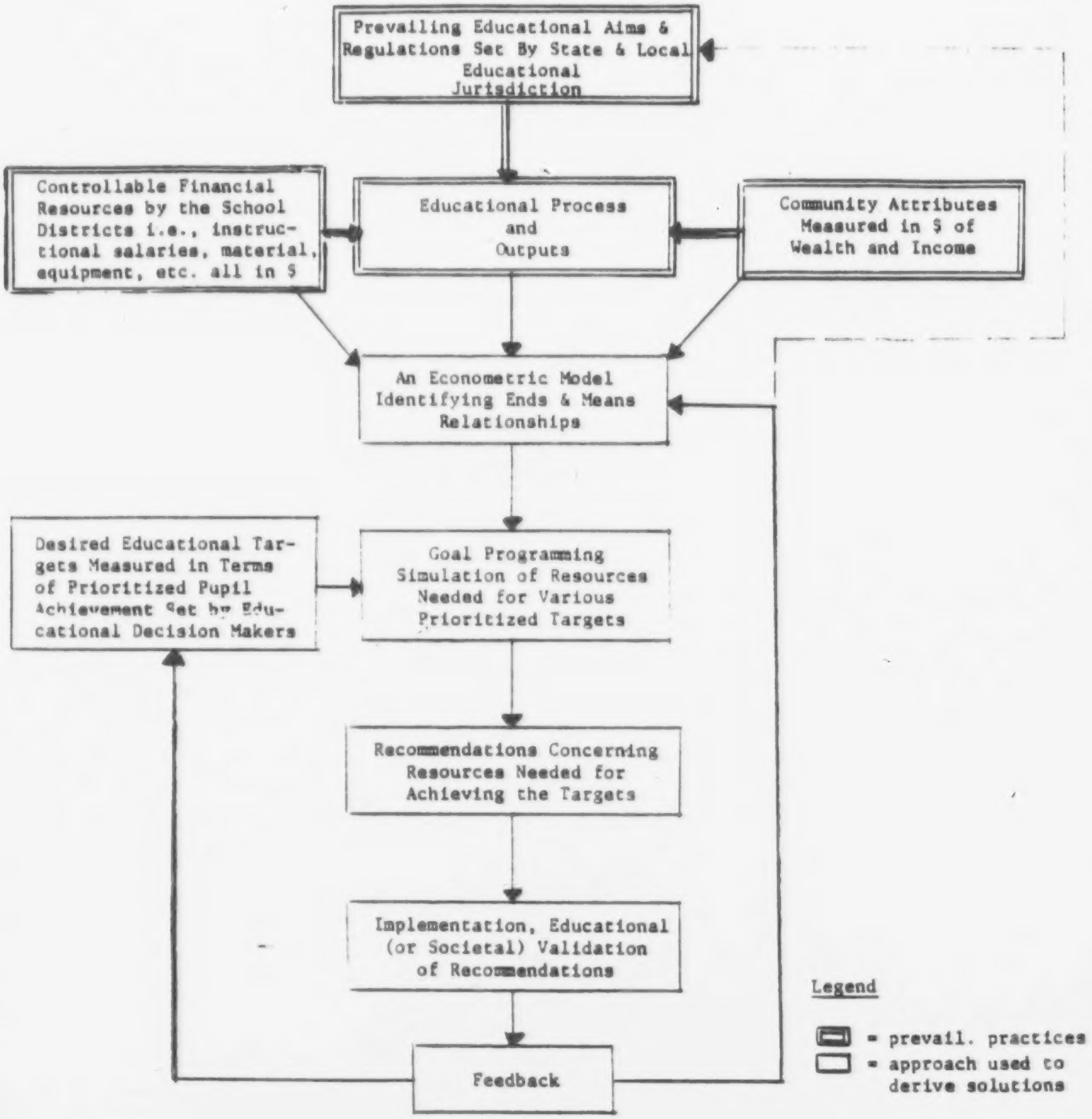
Upon executing this approach, inferences concerning resource allocation policies can be drawn from the information generated by the goal programming, namely:

- recommendation concerning alternative courses of action;
- validation of the recommendations through implementation experimentation.

The conceptual resource allocation process is presented schematically in Chart 3.1. Notice that the prevailing administrative practices and the various steps have been "interfaced" in this chart. To test the applicability of this resource allocation procedure solutions for various scenarios were simulated. These scenarios reflect potential conditions that may be faced by various types of school districts.

CHART 3.1

Schematic Representation of Resource Allocation Procedure


Prevailing Educational Aims & Regulations Set By State & Local Educational Jurisdiction
Controllable Financial Resources by the School Districts i.e., instructional salaries, material, equipment, etc. all in $
Educational Process and Outputs
Community Attributes Measured in $ of Wealth and Income
An Econometric Model Identifying Ends & Means Relationships
Desired Educational Targets Measured in Terms of Prioritized Pupil Achievement Set by Educational Decision Makers
Goal Programming Simulation of Resources Needed for Various Prioritized Targets
Recommendations Concerning Resources Needed for Achieving the Targets
Implementation, Educational (or Societal) Validation of Recommendations
Feedback
Legend
= prevail. practices
= approach used to derive solutions

Hence, upon consultation with several state administrators it was decided to derive solutions for the following types of cases:

- a property poor municipal school system;
- a suburban district whose income per return is below average;
- a district with an average income per return;
- a district whose income per return is above average.

Since the solutions for these cases were derived through the application of a linear goal programming in conjunction with the aforementioned logistic model, the recapituation of the logistic model is now in order. Recall that the structure of each of the "transformed" logistic equations of that model as was noted elsewhere (see Chapter II) can be expressed as;

$$Q_{ij} = \ln(O_{ij}/1-O_{ij}) = a_i + \sum_{k=2}^{K} b_k FRV_{k,j} + \sum_{l=1}^{L} c_l TSCP_{l,j} + \sum_{m=1}^{M} d_m COM_{m,j} + \sum_{n=1}^{N} e_n APNX_{n,j} + U_{i,j}$$

Where;

Q_{ij} = transformed dependent variable concerning the "i^{th}" outcome and "j^{th}" school

ln = natural log symbol

$FRV_{k,j}$ = input or financial expenditure variable under the control of the school district - an explanatory variable denoting expenditure (per pupil) by function "k" (i.e., salaries, expenditures on equipment, material, contractual, etc. of school district "j"

$TSCP_{l,j}$ = teacher or school characteristic index "l" - a nonfinancial explanatory variable observed in school district "j"

$COM_{m,j}$ = community index "m" - an explanatory variable beyond the school control denoting the socio-economic condition of district "j"

$APNX_{n,j}$ = trend scholastic performance index "n" (previous time period) observed in school district "j" - an explanatory variable

$U_{i,j}$ = a residual (or error term) associated with the outcome "i" and school district "j"

a_i, b_k, c_l, d_m, e_n = estimated parameters (coefficients) associated with their respective explanatory variables - their values are determined (or calibrated) empirically

$\sum$ = summation symbol

Notice that the left hand side of this theoretical equation (i.e., dependent variable) is not a probability variable, rather it is a transformed variable. Such transformed logistic equations were used, because they lend themselves to the application of a regression technique for the purpose of estimating the unknown value of the coefficients of the 28 (logistic) equations of the model. Each of these equations is concerned with a particular educational outcome. Also, these transformed logistic equations lend themselves to be applied in conjunction with the goal programming technique. Hence, the desired educational targets in this instance are analogously related to the dependent variables of the logistic model, whereas the corresponding financial resources needed to attain these targets were estimated in terms of variables X_2 - X_{47}.

The application of the goal programming technique to the financial resource allocation problem required the transfer of certain variables, that were not to be manipulated, to the right hand side of the goal programming tableau. Such a transfer is analogous to the transfer of variables from the right hand side of the logistic equations to their left hand side. Hence, variables depicting resources which are beyond the school's control along with school's nonfinancial resources variables appearing in each of the equations were transferred to the right hand side of the goal programming tableau.

Specifically, nonfinancial variables (X_i) no. 48-73, 76, 78-82, 86 and 93 and their respective coefficients along with the intercept (constant) appearing in any given equation, were aggregated into a constant term. Consequently, this term was transferred to the right hand side of the tableau. In doing so, the socioeconomic and other attributes which influence the scholastic outcomes were accounted for even though some of them are said to be beyond the control of the school. Therefore, the estimated coefficients of the financial variables (2-47) which were found to be statistically significant, became the parameters of the goal programming model. The various desired educational targets on the other hand, were specified in terms of the transformed (dependent) variables (Q_i), as was depicted earlier in Section II.

B. The Goal Programming Model Used in This Study

Whereas the conceptual overview of the educational resource allocation was presented in the previous section, details of the goal programming model used to simulate the various scenarios are briefly described in this section. A total of 54 objectives and restrictions are included in this model, each a function of a subset of about 80 explanatory variables which were displayed earlier in Table 3.1. The objectives were grouped into 3 classes:

- educational achievement objectives;
- budgetary constraints and restrictions;
- technical explanatory variable relationships.

The scholastic target values (goals) for the educational objectives were determined through consultation with administrators and educators for school districts with widely varying characteristics. The budgetary constraints were bounded by dollar amounts based on current spending levels in each district. As was noted in Table 3.1, the set of explanatory variables were grouped into 2 classes:

- financial variables (1-47);
- nonfinancial variables (48-73, 76, 78-82, 86, 93).

Since only the financial variables are being manipulated in the goal program, all nonfinancial variables, along with their coefficients, were aggregated into a constant term and transferred to the right hand side of the goal programming tableau. In other words, for each school district analyzed by this model, the specific values of the nonfinancial variables (and their respective parameters) were used to create a unique constant term. Hence, Table 3.2 summarizes which explanatory variables were retained in each educational outcome equation and which ones were aggregated into a constant term and consequently moved to the right hand side of the tableau.

Although 30 scholastic objectives were proposed, only 28 objectives were ultimately defined inasmuch as objectives 16 and 27 were dropped because no logistic equations were constructed for outcomes Q_{16} and Q_{27}. Moreover, of the 47 financial variables retained in the model, only 20 proved to be statistically significant in one or more of the educational (logistic) outcome equations. Thus, financial variables were redefined and indexed from 1 to 20. The relationship between the redefined variables, Y_i, and the original financial variables, X_i, were denoted in Table 3.1. Also, the variables prefixed by "*" (in Table 3.1) are summation variables summing expenditures over some subset of the financial variables.

For example:

$$*X_{18} = X_{13} + X_{15} + X_{16} + X_{17}$$

or, using the newly defined goal programming (G.P.) variables,

$$Y_7 = Y_3 + Y_4 + Y_5 + Y_6$$

Similarly,

$$Y_{11} = Y_8 + Y_9 + Y_{10}$$

$$Y_{18} = Y_{16} + Y_{17}$$

Converting these equations to a form suitable for goal programming, the following can be defined:

TABLE 3.2

LIST OF VARIABLES RETAINED IN AND REMOVED FROM THE OUTCOME EQUATIONS

Goal Prog. Model Code	Logistic Model Code	Financial Variables-Retained	Variables Moved to the Right Hand Side (Of The Tableau)
Q(1)*	Q(1)	X_{11}, X_{13}, X_{15}, X_{19}, X_{21}, X_{34}, X_{44}	X_{60}, X_{62}, X_{69}
Q(2)*	Q(2)	X_{11}, X_{13}, X_{44}, X_{47}	X_{48}, X_{69}, X_{70}
Q(3)*	Q(3)	X_{2}, X_{19}, X_{33}, X_{47}	X_{48}, X_{52}, X_{61}, X_{69}
Q(4)*	Q(4)	X_{13}, X_{17}, X_{33}, X_{44}	X_{48}, X_{60}, X_{69}, X_{70}
Q(5)*	Q(5)	X_{2}, X_{13}, X_{22}, X_{44}	X_{48}, X_{51}, X_{60}, X_{61}
Q(6)*	Q(6)	X_{28}	X_{48}, X_{52}, X_{60}, X_{69}, X_{70}
Q(7)*	Q(7)	X_{17}, X_{28}, X_{33}	X_{54}, X_{78}
Q(8)*	Q(8)	X_{18}, X_{35}	X_{49}, X_{52}, X_{59}, X_{79}
Q(9)*	Q(9)	X_{2}, X_{11}	X_{59}, X_{60}, X_{69}
Q(10)*	Q(10)	X_{16}, X_{19}, X_{34}, X_{40}, X_{41}	X_{72}, X_{80}
Q(11)*	Q(11)	X_{11}, X_{13}, X_{33}	X_{66}
Q(12)*	Q(12)	X_{11}, X_{13}, X_{16}, X_{17}, X_{23}, X_{33}, X_{40}, X_{41}	None
Q(13)*	Q(13)	X_{13}, X_{23}, X_{33}, X_{43}	X_{49}, X_{51}, X_{54}, X_{72}
Q(14)*	Q(14)	X_{11}, X_{13}, X_{33}	X_{60}, X_{67}, X_{80}, X_{82}
Q(15)*	Q(15)	X_{11}, X_{13}, X_{28}, X_{34}	X_{69}
----	Q(16)	- - - - - - No Equation Calibrated - - - - - - -	
Q(16)*	Q(17)	X_{13}, X_{15}, X_{17}, X_{28}	X_{61}
Q(17)*	Q(18)	X_{16}	X_{51}, X_{60}, X_{70}
Q(18)*	Q(19)	X_{28}, X_{43}	X_{54}, X_{64}
Q(19)*	Q(20)	X_{13}, X_{17}, X_{23}, X_{44}, X_{47}	X_{80}, X_{81}
Q(20)*	Q(21)	X_{13}, X_{28}	X_{60}, X_{69}, X_{80}
Q(21)*	Q(22)	X_{17}, X_{33}, X_{47}	X_{51}, X_{54}, X_{68}, X_{70}, X_{80}
Q(22)*	Q(23)	X_{28}	X_{52}, X_{59}, X_{60}, X_{61}, X_{69}, X_{70}
Q(23)*	Q(24)	X_{11}, X_{13}, X_{15}, X_{17}, X_{28}, X_{40}, X_{41}	X_{52}, X_{69}, X_{82}
Q(24)*	Q(25)	X_{11}, X_{23}	X_{61}, X_{68}, X_{70}, X_{72}

TABLE 3.2 (Con't.)

Goal Prog. Model Code	Logistic Model Code	Financial Variables-Retained	Variables Moved to the Right Hand Side (Of The Tableau)
Q(25)*	Q(26)	X_{16}, X_{17}, X_{23}	X_{80}, X_{81}
----	Q(27)	- - - - - - No Equation Calibrated - - - - - - -	
Q(26)*	Q(28)	X_{11}	$X_{60}, X_{68}, X_{69}, X_{93}$
Q(27)*	Q(29)	$X_{11}, X_{13}, X_{15}, X_{17}, X_{43}$	$X_{52}, X_{60}, X_{69}, X_{86}$
Q(28)*	Q(30)	$X_{18}, X_{28}, X_{35}, X_{43}$	$X_{49}, X_{52}, X_{54}, X_{70}, X_{72}$

Legend

Q(i)* = Goal Prog. Code

Q(i) = Logistic Model Code

Objective 30: $Y_3 + Y_4 + Y_5 + Y_6 - Y_7 + d_{30}^- - d_{30}^+ = 0$

Objective 31: $Y_8 + Y_9 + Y_{10} - Y_{11} + d_{31}^- - d_{31}^+ = 0$

Objective 32: $Y_{16} + Y_{17} - Y_{18} + d_{32}^- - d_{32}^+ = 0$

The objectives must be observed at Priority 1 to force equality and both deviation variables are in the achievement function for each objective. Since a minimal expenditure must be maintained in each financial category, each "starred" summation variable was bounded to be no less than 50% of present spending levels at a particular school district. Hence, for example, the lower bound of variables X_{44} and X_{47} was set at 50% of the current spending level. The corresponding goals for these bounding objectives were defined:

$G_i = (.5)$ (presenting spending level for $Y_{K(i)}$)

and

Objective i: $Y_{K(i)} + d_i^- - d_i^+ = G_i$,

where

$i = 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43$

$K(i) = 1, 2, 7, 11, 12, 13, 14, 15, 18, 19, 20$

The deviation variable, d_i^- was placed in the achievement function at Priority 1. If d_i^- is driven to zero by the goal program and d_i^+ takes on some positive value, $Y_{K(i)} \geq G_i$, as required.

To alleviate the possibility that logistics equations prescribe unrealistically high expenditures in each financial category, an upper bound of $7000/pupil was given. This figure is approximately equal to the total budget per student for a high income (per return) school district. Hence, the corresponding goals for these upper bounding objectives were defined as:

Objective i: $Y_{K(i)} + d_i^- - d_i^+ = 7000$ dollars per pupil.

where;

$i = 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54$

$K(i) = 1, 2, 7, 11, 12, 13, 14, 15, 18, 19, 20$

The positive deviation variable, d_i^+, is placed in the achievement function and minimized at Priority 1. If the positive deviation d_i^+ is zero and the negative deviation $d_i^- \geq 0$, then total budget $Y_{K(i)} \leq 7000$, as required.

Since the total expenditures across all financial categories must not exceed the budget we defined G_{29} to be total budget/pupil. Hence, G_{29} was defined as follows:

$$Y_1 + Y_2 + Y_7 + Y_{11} + Y_{12} + Y_{13} + Y_{14} + Y_{15} + Y_{18} + Y_{19} + Y_{20} + d_{29}^- - d_{29}^+ = G_{29}$$

In this instance the positive deviation variable, d_{29}^+, was minimized at priority 1. Hence, if $d_{29}^+ = 0$ and $d_i^- \geq 0$, then total expenditures are less than or equal to the total budget/pupil, as required.

Recall that the logistics model provides the first 28 objectives of the goal program. Since the "transformed" logistics equations are linear, the deviation variables were applied to them. Therefore, the corresponding goals were defined:

$$G_i = \ln [O_i/(1-O_i)]$$

where;

O_i = probabilistic target value for educational outcome i

ln = natural log

and,

Objective i: $\sum_{k=1}^{K} b_{ik}Y_k + d_i^- - d_i^+ = G_i \qquad i = 1,2,3,\ldots,28$

It should be noted that for $i = 1,2,..,27$, the negative deviation d_i^- was minimized at a priority level selected by educators, whereas for $i = 28$, the positive deviation d_i^+ is minimized. In other words, Objective 28 was used to minimize the dropout rate and in this sense the optimization is, therefore, reversed from the first 27 objectives.

IV. THE SCENARIOS

To demonstrate the applicability of the goal programming model to the problem of financial resource allocation within school districts, four cases were analyzed. While the cases represent a diversity of school districts, the goal programming model has been employed to address a common administrative predicament which can be stated as follows:

- Granted the socioeconomic and nonfinancial attributes of the district in question, how should its budget(s) be distributed over the various financial categories (functions) so as to allow that district to "produce" outcome levels which are .05 above their current scholastic achievement probability, without changing its current state or operational structure.

To address this research predicament, we have applied this model to ascertain solutions for four scenarios, each representing a particular type of district:

- Scenario 1 represents a large municipal and property poor district whose income per return is said to be \$17,725 - containing about 8000 pupils.*
- Scenario 2 represents a large suburban school containing approximately 7000 pupils whose income per return is \$22,700 which is below the statewide average.
- Scenario 3 represents a school district whose income per return (\$29,000) is said to be average and its enrollment is about 1950 pupils.
- Scenario 4 represents a school district whose income per return (\$35,000) is said to be above the statewide average and its enrollment is approximately 2320 pupils.

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*The statewide sample average is said to be 3,000 pupils.

For expository purposes, solutions for Scenarios 1 and 2 were simulated under two budgetary conditions, namely: a) their current total budget per pupil, or b) the current budget + 15%, and c) a budget of $6685 per pupil which is the average budget of the upper 50% of sampled districts. The third budget configuration ($6685) was selected to explore whether additional financial resources will improve the scholastic outcomes of such low income districts. The remaining scenarios (3 and 4) were simulated while using the current budget of the districts in question. It was felt that in scenarios 3 and 4, districts could improve their scholastic outcomes by merely applying a strategic planning analysis (see Greenborough, 1980), through the application of a management science technique. Finally, the district's attributes (which are beyond the school's control) were accounted for by transferring the nonfinancial variables and their coefficients along with the equation's constant to the right hand side of the goal programming tableau. Therefore, only the remaining financial variables found (in the logistic equations) were manipulated by the goal programming model, while searching for a solution for the said scenarios.

Consequently, other information regarding the schools in question was entered into the goal programming tableaux, namely:

- proportion value of the desired scholastic outcomes (targets);
- preemptive priority levels and weights assigned within a priority level to each of the desired scholastic targets;
- total available budget(s) per pupil;
- parameters denoting the technical relationships between each of the financial categories and the desired scholastic targets (outcomes);
- lower and upper bounds for each of the financial categories.

The preemptive scholastic targets for the four scenarios were set at .05 above the current probabilistic outcome levels of the districts in question. For instance, the desired scholastic outcome concerning PEP - Reading Grade 3 test is .92 and .89 for property poor (scenario 1) and low income income districts (scenario 2), respectively. On the other hand, the priority level and weight associated with this test were pegged at 2 and 20 (%), respectively. It was hypothesized that a yearly budgetary threshold of $3500-4500 (per pupil) will be needed by the property poor and low income districts to attain their respective scholastic targets (outcomes). Hence, for expository purposes, the four scenarios were simulated under the following budget configurations:

Scenario	Current Budget	Current Budget +15%	High Budget
1	--	$3500	$6685
2	$4682	--	$6685
3	$6757	--	--
4	$6631	--	--

The goal programming parameters as was noted earlier, are composed of the (logistic model's) financial variables coefficients which were retained in the tableaux as was denoted in Table 3.2. Finally, the lower and upper bounds of the financial categories (Y_1 through Y_{20}) were pegged according to the criteria discussed earlier in Section III of this chapter.

Upon incorporating this information into the goal programming tableaux and the execution of the goal programming model, the following estimations were obtained for each of the scenarios:

- attainable scholastic targets or outcomes - measured as a proportion;

- corresponding financial resource by categories needed to produce the desired outcomes.

The findings of this endeavor are presented below.

A. Scenario 1 - Solutions

This scenario as was noted earlier, was analyzed under two budget configurations. It was done for the purpose of exploring whether additional financial resources will enable a property poor district to "produce" an enhanced set of scholastic outcomes. The findings regarding the attainability of these preemptive targets (i.e., desired outcomes) and the corresponding fund distribution over the various financial categories (Y_1 - Y_{20}) are presented in Tables 3.3-A and 3.3-B, respectively. A cursory examination of Tables 3.3-A and 3.3-B will reveal that they contain respectively, 5 and 4 columns labeled as follows:

Col.No.	Table 3.3-A	Table 3.3-B
1	Desired Scholastic Outcome	Current Allotment
2	Priority and Weights	Current Budget Solutions (by categories Y_1 - Y_{20})
3	Target Attainable Under Current Budget (configuration)	Current Budget + 15% Solutions
4	Target Attainable Under Current Budget + 15%	High Budget Solutions
5	Target Attainable Under the Budget of $6685	

Notice that in Table 3.3-A, the desired scholastic targets for Q^*_{19} and Q^*_{24} are denoted by N/A inasmuch as no test in these two subjects was conducted by the school in question. Also, no information is provided relative to outcomes Q_{16} and Q_{27}, due to the fact that no logistic equation was developed for these tests. Also notice that Q^*_{17} and Q^*_{20} solutions are denoted by (**), indicating that dubious attainable target

TABLE 3.3A
SCENARIO 1 - SCHOLASTIC ACHIEVEMENT

12/5/88
Corre:ted 12/6/88

G.P. Item No.	Logistic Model Item Code and Name	(Col. 1) Desired Scholastic Outcome	(Col. 2) Priority/ Weight	Goal Programming Solutions (Col. 3) Target Attained Under Current Budget	(Col. 4) Target Attainable Under Current Budget + 15%	(Col. 5) Target Attainable Under a Budget of $6685 Per enrolees
Q(1)*	Q(1) PEP-Reading Grade 3	.92	2 / 20		.92	.999
Q(2)*	Q(2) PEP-Math Grade 3	.97	1 / 33.3		.97	.976
Q(3)*	Q(3) PEP-Writing Grade 5	.95	2 / 20		.9499	.9499
Q(4)*	Q(4) PEP-Reading Grade 6	.89	2 / 20		.95	.961
Q(5)*	Q(5) PEP-Math Grade 6	.89	1 / 33.3		.99	.994
Q(6)*	Q(6) PCT-Reading Grade 6	.99	2 / 20		.942	.942
Q(7)*	Q(7) RCT-Math	.73	1 / 33.3		.882	.882
Q(8)*	Q(8) RCT-Reading	.77	2 / 20		.7699	.7699
Q(9)*	Q(9) RCT-Writing	.83	2 / 20		.999	.999
Q(10)*	Q(10) REG-Bookkeeping	.95	5 / 20		.917	.95
Q(11)*	Q(11) REG-Business Law	.999	5 / 20		.948	.95
Q(12)*	Q(12) REG-Business Math	.82	3 / 10		.8199	.8199
Q(13)*	Q(13) REG-Comp. English	.90	4 / 20		.87	.94
Q(14)*	Q(14) REG-Comp. French	.99	5 / 20		.999	.9783
Q(15)*	Q(15) REG-Comp. German	.93	5 / 20		.964	.93
-----	Q(16) REG-Comp. Italian	--	- / -		--	--
Q(15)*	Q(17) REG-Comp. Latin	.999	5 / 20		.981	.99
Q(17)*	Q(18) REG-Comp. Spanish	.94	5 / 20		** .0592	** .092
Q(18)*	Q(19) REG-Math. 9	.96	3 / 20		.93	.93
Q(19)*	Q(20) REG-Math. 10	N/A	3 / 15		N/A	N/A
Q(20)*	Q(21) REG-Math. 11	.80	3 / 10		.79	.84
Q(21)*	Q(22) REG-Seq. Math I	.72	3 / 20		.7199	.72
Q(22)*	Q(23) REG-Seq. Math II	.82	3 / 15		.88	.882
Q(23)*	Q(24) REG-Seq. Math III	N/A	3 / 10		N/A	N/A
Q(24)*	Q(25) REG-Biology	.91	4 / 20		.92	.97
Q(25)*	Q(26) REG-Chemistry	.81	4 / 20		.72	.998
----	Q(27) REG-Earth Science	--	- / -		--	--
Q(26)*	Q(28) REG-Physics	.92	4 / 20		.89	.8978
Q(27)*	Q(29) REG-Comp. Soc. Stud.	.82	4 / 20		.912	.848
Q(28)*	Q(30) Dropout	.0455	6 / 100		**	**

Q(i)* = Goal Proc. Code	PRIORITY→	/	WEIGHT WITHIN PRIORITY

Q(i) = Logistic Model Code

** = Error/no solution

N/A = Test not administered

TABLE 3.3B
SCENARIO 1 - CORRESPONDING FINANCIAL REQUIREMENTS

12/5/88
Corrected 12/6/88

G.P. Item No.	Logistic Model Item Code and Name	Current Allotment (Col. 1)	Goal Programming Solutions A. Current Budget (Col. 2)	B. Current Budget + 15% (Col. 3)	C. High Budget ($6685) (Col. 4)
	X(1) Instructional Chief School Adm. (per Total Enrollment)				
Y(1)	*X(2) Total Chief School Adm.	5.6		730	743
	X(3) Instructional Salaries ----- ADMN./IMPROV.				
	X(4) Non-Instruct. Salaries "				
	X(5) Equipment/Supply "				
	X(6) Contractual + BOCES "				
	X(7) Total Curriculum Develop. "				
	X(8) Total Supervision "				
	X(9) Total Research/Education/Plan. "				
	X(10) Total Training "				
Y(2)	*X(11) Total Instr./Administ./Improv. "	131.60		66.0	66.0
	X(12) Teachers Salaries K-6 ---- INSTRUC.				
Y(3)	X(13) Teachers Salaries Total "	1340.0		1434.0	1874.0
	X(14) Substitute Teacher Salaries "				
Y(4)	X(15) Non-Instructional Salaries "	26.45			324
Y(5)	X(16) Equipment/Supply/Text Books "	84.40			708.0
Y(6)	X(17) BOCES/Contractual/Tuition "	42.40			0.0
Y(7)	*X(18) Total Instructional Teaching "	1540.1		1434	2907.0
Y(8)	X(19) Instructional Salaries ---- MEDIA	19.6		0.0	0.0
	X(20) Non-Instructional Salaries "				
Y(9)	X(21) Equipment/Supply "	13.10		4.2	739.0
Y(10)	X(22) BOCES/Contractual "	19.55		23.8	
Y(11)	*X(23) Total Instructional Media "	54.85		28.0	739.0
	X(24) Instructional Salaries ---- PUPIL SVS.				
	X(25) Non-Instructional Salaries "				
	X(26) Equipment/Supply "				
	X(27) BOCES/Contractual "				
Y(12)	*X(28) Total Pupil Services "	102.35		51.0	51.0
	X(29) Instructional Salaries "				
	X(30) Non-Instructional Salaries-- COCURRIC./ATHLETIC				
	X(31) Equipment/Supply "				
	X(32) BOCES Serv./Contractual "				
Y(13)	*X(33) Total Cocurricular "	11.85		[141.5]	[160.0]
Y(14)	*X(34) Total Interscholastic Athletic "	20.25		[283.5]	[320.0]
Y(15)	*X(35) Total Cocurric./Athletic "	32.10		425.0	480.0
	X(36) Instructional Salaries ---- COMM. SVS.				
	X(37) Non-Instructional Salaries "				
	X(38) Equipment/Supply "				
	X(39) BOCES/Contractual "				
Y(16)	X(40) Total Community/Recr. "	0.		0.0	0.0
Y(17)	X(41) Total Youth Program "	0.		0.0	0.0
	X(42) Total Civic Activities "				
Y(18)	*X(43) Total Commun./Youth/Civic "	0		0.0	0.0
Y(19)	*X(44) Total Emply. Benefit ---- OVERHEAD	687.35		344	344
	X(45) Total Operation & Maint. "				
	X(46) Total Bus Transportation "				
Y(20)	*X(47) Sum of [X(45) + X(46)] "	456.75		268	268

Legend

Y(i) = Goal Prog. Code
X(i) = Logistic Model Code
*X(i) = Summation Variable
[ ] = Suggested Allotment

values were derived for these scholastic targets. Since the priority for Q^*_{28} was set at the lowest level (no. 6), no satisfactory solution was derived by the program under the said budget configurations. Similarly, the lack of attainable targets for Q^*_{17} is also due to the low priority value of this outcome.

A cursory comparison of figures found in column 5 of Table 3.3-A against those found in column 1, will reveal that all but four of the desired scholastic targets (listed in column 5) are attainable under a high budget configuration (e.g., \$6685). On the other hand, nine of the desired outcomes cannot be attained under the current budget + 15% (\$3500) configuration. However, these unattainable targets are above the current scholastic achievement level.

The corresponding financial resources (by categories Y_1 - Y_{20}) needed to realize the attainable scholastic targets along with the current allotment are tabulated in Table 3.3-B. A comparison of columns 3 and 4 information against the current allotment information found in column 1 of this table, will reveal some deviation between the current allotment and the goal programming solutions. For instance, the current allotment for financial category Y_1 is \$3.30, whereas the goal programming solutions call for a much higher allocation for this category (e.g., \$730). On the other hand, under the current budget + 15% (e.g., \$3500) configuration no funds were allocated (by the model) to categories Y_4 and Y_5 (see column 3), whereas under the high budget configuration (column 4) \$324 and \$708 were assigned respectively to these categories. Also, notice that the current allotment for financial category Y_{15} is \$32.10 whereas the goal programming solutions regarding this category (as denoted in columns 3 and 4) are \$425 and \$480, respectively. In contrast, the goal programming solutions regarding categories Y_{19} and Y_{20} (found in columns 3 and 4) are about half of the current allotment (see column 1) for these categories.

Certain inferences can be drawn from the comparisons in the previous paragraph. For example, the goal programming solutions regarding categories Y_4 and Y_5 seem to confirm the prevailing administrative reaction to a financial crisis. Under a lean budget configuration, educators tend to direct most of the available resources toward direct instructional activities [see for example, Hartman, 1985]. On the other hand, the solutions regarding category Y_1, which is at the upper bound for both (low and high) budget configurations, imply that a much greater effort (regarding the daily operation) must be devoted by management to assure the realization of the desired educational targets as was advocated by Greenborough (1980) and others. Conversely the goal programming solutions regarding category Y_{15} which is much larger than the current allotment (column 1) under both budget configurations (columns 3 and 4), seems to confirm a New Jersey study which showed a positive relationship between co-curricular expenditure and pupil performance [see Spottheim/Libassi/Wilson, 1984, Chapter III]. In contrast, the goal programming solutions relative to category Y_{19}, which is at the lower bound, implies that this category has little or no bearing upon the scholastic targets. And as such, the financial expenditures on this category should be minimized with respect to the particular district used to simulate solutions for scenario 1. Finally, the goal programming solutions for category Y_{20} imply that the "externalities", amenities and services which this small city is endowed with, can be "internalized" (exploited) by the district, thereby, allowing it to reduce its Y_{20} expenditures.

B. Scenario 2 - Solutions

Whereas the previous scenario dealt with a property poor district, this scenario represents a district whose income per return ($22,710) is below the (statewide) sample average. Since the estimated (per pupil) budget of this district is $1000 over the previous district, it was decided to explore this scenario under its current (1985) budget ($4682) and high budget ($6682) configurations. Hence, the goal programming solutions for this scenario can be found in Tables 3.4-A and 3.4-B. Notice that the layout of these tables is identical to the tables displayed in scenario 1 section.

A cursory examination of Table 3.4-A will reveal that the school under study (in this scenario) did not administrate tests relative to Q^*_{15}, Q^*_{16}, Q^*_{18}, Q^*_{19} and Q^*_{23}. Therefore, no desired targets were set for these outcomes. Also, no desired targets were set for outcomes Q_{16} and Q_{27} inasmuch as no equation was calibrated for these outcomes. Finally, the solutions for Q^*_{17} and Q^*_{28} (just as for the previous scenario) are of dubious value and as such they are marked by (**).

A cursory comparison of columns 3 and 5 to column 1 (of Table 3.4-A) will reveal that all but two desired targets (Q^*_6 and Q^*_{14}) are attainable under both budget configurations. Also a comparison between the figures displayed in column 3 and those of column 5 will reveal numerical similarities.

The financial ramification of these findings is that the desired scholastic targets are by and large attainable under the current (per pupil) budget configuration ($4683). To realize these targets however, the goal programming solutions call for the distribution of this budget over the various financial categories in a manner which is vastly

TABLE 3.4A
SCENARIO 2 - SCHOLASTIC ACHIEVEMENT

12/5/88
Corrected 12/6/88

G.P. Item No.	Logistic Model Item Code and Name	(Col. 1) Desired Scholastic Outcome	(Col. 2) Priority/ Weight	Goal Programming Solutions (Col. 3) Target Attained Under Current Budget	(Col. 4) Target Attainable Under Current Budget + 15%	(Col. 5) Target Attainable Under a Budget of $66A5 Per enrolees
Q(1)*	Q(1) PEP-Reading Grade 3	.89	2 / 20	.89		.94
Q(2)*	Q(2) PEP-Math Grade 3	.93	1 / 33.3	.95		.95
Q(3)*	Q(3) PEP-Writing Grade 5	.97	2 / 20	.97		.97
Q(4)*	Q(4) PEP-Reading Grade 6	.82	2 / 20	.91		.91
Q(5)*	Q(5) PEP-Math Grade 6	.78	1 / 33.3	.99		.99
Q(6)*	Q(6) PCT-Reading Grade 6	.96	2 / 20	.94		.94
Q(7)*	Q(7) RCT-Math	.70	1 / 33.3	.90		.90
Q(8)*	Q(8) RCT-Reading	.78	2 / 20	.78		.78
Q(9)*	Q(9) RCT-Writing	.70	2 / 20	.99		.999
Q(10)*	Q(10) REG-Bookkeeping	.60	5 / 20	.99		.599
Q(11)*	Q(11) REG-Business Law	.80	5 / 20	.90		.90
Q(12)*	Q(12) REG-Business Math	.999	3 / 10	.99		.99
Q(13)*	Q(13) REG-Comp. English	.83	4 / 20	.98		.99
Q(14)*	Q(14) REG-Comp. French	.99	5 / 20	.96		.96
Q(15)*	Q(15) REG-Comp. German	N/A	5 / 20	N/A		N/A
-----	Q(16) REG-Comp. Italian	--	- / -	--		--
Q(15)*	Q(17) REG-Comp. Latin	N/A	5 / 20	N/A		N/A
Q(17)*	Q(18) REG-Comp. Spanish	.99	5 / 20	** .133		** .20
Q(18)*	Q(19) REG-Math. 9	N/A	3 / 20	N/A		N/A
Q(19)*	Q(20) REG-Math. 10	N/A	3 / 15	N/A		N/A
Q(20)*	Q(21) REG-Math. 11	.76	3 / 10	.76		.76
Q(21)*	Q(22) REG-Seq. Math I	.87	3 / 20	.87		.87
Q(22)*	Q(23) REG-Seq. Math II	.85	3 / 15	.85		.85
Q(23)*	Q(24) REG-Seq. Math III	N/A	3 / 10	N/A		N/A
Q(24)*	Q(25) REG-Biology	.76	4 / 20	.92		.92
Q(25)*	Q(26) REG-Chemistry	.77	4 / 20	.77		.99
----	Q(27) REG-Earth Science	--	- / -	--		--
Q(26)*	Q(28) REG-Physics	.80	4 / 20	.82		.88
Q(27)*	Q(29) REG-Comp. Soc. Stud.	.70	4 / 20	.99		.99
Q(28)*	Q(30) Dropout	.03	6 / 100	**		**

Legend

Q(i)* = Goal Prog. Code

PRIORITY → / WEIGHT WITHIN PRIORITY

Q(i) = Logistic Model Code

** = Error/no solution

N/A Test not administered

TABLE 3.4B
SCENARIO 2 - CORRESPONDING FINANCIAL REQUIREMENTS

12/5/88
Corrected 12/6/88

G.P. Item No.	Logistic Model Item Code and Name	Current Allotment (Col. 1)	Goal Programming Solutions A. Current Budget (Col. 2)	B. Current Budget + 15% (Col. 3)	C. High Budget ($6685) (Col. 4)
	X(1) Instructional Chief School Adm. . . (per Total Enrollment)				
Y(1)	*X(2) Total Chief School Adm.	16.05	896.0		894
	X(3) Instructional Salaries ----- ADMN./IMPROV.				
	X(4) Non-Instruct. Salaries "				
	X(5) Equipment/Supply "				
	X(6) Contractual + BOCES "				
	X(7) Total Curriculum Develop. "				
	X(8) Total Supervision "				
	X(9) Total Research/Education/Plan. "				
	X(10) Total Training "				
Y(2)	*X(11) Total Instr./Administ./Improv. "	269.3	135		135
	X(12) Teachers Salaries K-6 ---- INSTRUC.				
Y(3)	X(13) Teachers Salaries Total "	1932.0	1374.0		1374.0
	X(14) Substitute Teacher Salaries "				
Y(4)	X(15) Non-Instructional Salaries "	19.6	0.0		271.5
Y(5)	X(16) Equipment/Supply/Text Books "	97.4	45.0		1603.8
Y(6)	X(17) BOCES/Contractual/Tuition "	96.0			0.0
Y(7)	*X(18) Total Instructional Teaching "	2202.1	1419.0		3249
Y(8)	X(19) Instructional Salaries ---- MEDIA				0.0
	X(20) Non-Instructional Salaries "				
Y(9)	X(21) Equipment/Supply "	12.0			41.0
Y(10)	X(22) BOCES/Contractual "	.27	41.0		0
Y(11)	*X(23) Total Instructional Media "	81.2	41.0		41.0
	X(24) Instructional Salaries ---- PUPIL SVS.				
	X(25) Non-Instructional Salaries "				
	X(26) Equipment/Supply "				
	X(27) BOCES/Contractual "				
Y(12)	*X(28) Total Pupil Services "	121.4	61.0		61.0
	X(29) Instructional Salaries "				
	X(30) Non-Instructional Salaries-- COCURRIC./ATHLETIC				
	X(31) Equipment/Supply "				
	X(32) BOCES Serv./Contractual "				
Y(13)	*X(33) Total Cocurricular "	0.0	[143.70]		[170.0]
Y(14)	*X(34) Total Interscholastic Athletic "	26.70	[287.8]		[337.0]
Y(15)	*X(35) Total Cocurric./Athletic "	26.70	431.5		507
	X(36) Instructional Salaries ---- COMM. SVS.				
	X(37) Non-Instructional Salaries "				
	X(38) Equipment/Supply "				
	X(39) BOCES/Contractual "				
Y(16)	X(40) Total Community/Recr. "	0.0	0.0		62.2
Y(17)	X(41) Total Youth Program "	0.0	22.0		88.4
	X(42) Total Civic Activities "				
Y(18)	*X(43) Total Commun./Youth/Civic "	.67	22.0		150.6
Y(19)	*X(44) Total Emply. Benefit ---- OVERHEAD	1156.0	578.0		578.0
	X(45) Total Operation & Maint. "				
	X(46) Total Bus Transportation "				
Y(20)	*X(47) Sum of [X(45) + X(46)] "	780.0	1.050.0		1,050.0

Legend

Y(i) = Goal Prog. Code
X(i) = Logistic Model Code
*X(i) = Summation Variable
[ ] = Suggested Allotment

different from the current allotment. For instance, the current allotment (in \$) by categories is as follows: $Y_1 = 16.05$; $Y_2 = 269.30$; $Y_3 = 1,932$; $Y_5 = 97.40$; $Y_{11} = 81.20$; $Y_{15} = 26.70$; $Y_{19} = 1,156.00$; and $Y_{20} = 780.80$, whereas the goal programming solutions call for the following distribution of funds: $Y_1 = 869$; $Y_2 = 135$; $Y_3 = 1,374$; $Y_5 = 45$; $Y_{11} = 41$; $Y_{15} = 431.5$; $Y_{19} = 578$; $Y_{20} = 1,050$.

The differences between the current allotment and goal programming solutions can be rationalized in the same manner as was discussed earlier in scenario 1. For instance, the goal programming solutions regarding category Y_1 imply that much greater effort must be devoted by management to assure the realization of the desired scholastic targets. The Y_{15} solutions on the other hand, seem to confirm the said New Jersey study, whereas the Y_{19} solutions imply that this category has little or no bearing upon the scholastic targets. In contrast, expenditure for category Y_{20} should be increased, because the area in which the district is located may lack the necessary "externalities" needed to sustain the viability of the district in question.

C. Scenario 3 - Solutions

The solutions for this scenario as was noted earlier, were obtained under a single budget configuration, inasmuch as the income per return (\$29,000) of the district in question is a statewide average. Hence, it was hypothesized that this district can attain the desired scholastic targets with an estimated (1985) budget of \$6757 per pupil.

The goal programming solutions for this scenario are displayed in Tables 3.5-A and 3.5-B. A cursory examination of Table 3.5-A will reveal that no targeted outcome is provided for Q^*_7, Q^*_8, Q^*_{16}, because test

TABLE 3.5A
SCENARIO 3 - SCHOLASTIC ACHIEVEMENT

12/5/88
Corre:ted 12/6/88

G.P. Item No.	Logistic Model Item Code and Name	(Col. 1) Desired Scholastic Outcome	(Col. 2) Priority/ Weight	Goal Programming Solutions (Col. 3) Target Attained Under Current Budget	(Col. 4) Target Attainable Under Current Budget + 15%	(Col. 5) Target Attainable Under a Budget of $6685 Per enrolees
Q(1)*	Q(1) PEP-Reading Grade 3	.79	2 / 20	.79		
Q(2)*	Q(2) PEP-Math Grade 3	.93	1 / 33.3	.972		
Q(3)*	Q(3) PEP-Writing Grade 5	.87	2 / 20	.87		
Q(4)*	Q(4) PEP-Reading Grade 6	.62	2 / 20	.97		
Q(5)*	Q(5) PEP-Math Grade 6	.75	1 / 33.3	.75		
Q(6)*	Q(6) PCT-Reading Grade 6	.96	2 / 20	.979		
Q(7)*	Q(7) RCT-Math	N/A	1 / 33.3	N/A	N/A	N/A
Q(8)*	Q(8) RCT-Reading	N/A	2 / 20	N/A	N/A	N/A
Q(9)*	Q(9) RCT-Writing	.25	2 / 20	.906		
Q(10)*	Q(10) REG-Bookkeeping	.81	5 / 20	.81		
Q(11)*	Q(11) REG-Business Law	.84	5 / 20	.85		
Q(12)*	Q(12) REG-Business Math	.999	3 / 10	.999		
Q(13)*	Q(13) REG-Comp. English	.90	4 / 20	.99		
Q(14)*	Q(14) REG-Comp. French	.98	5 / 20	.96		
Q(15)*	Q(15) REG-Comp. German	.999	5 / 20	.988		
-----	Q(16) REG-Comp. Italian	--	- / -	--	--	--
Q(15)*	Q(17) REG-Comp. Latin	N/A	5 / 20	N/A	N/A	N/A
Q(17)*	Q(18) REG-Comp. Spanish	.99	5 / 20	** .0002		
Q(18)*	Q(19) REG-Math. 9	.95	3 / 20	.95		
Q(19)*	Q(20) REG-Math. 10	.79	3 / 15	.99		
Q(20)*	Q(21) REG-Math. 11	.82	3 / 10	.82		
Q(21)*	Q(22) REG-Seq. Math I	.999	3 / 20	.946		
Q(22)*	Q(23) REG-Seq. Math II	.85	3 / 15	.915		
Q(23)*	Q(24) REG-Seq. Math III	.81	3 / 10	.827		
Q(24)*	Q(25) REG-Biology	.79	4 / 20	.976		
Q(25)*	Q(26) REG-Chemistry	.95	4 / 20	.897		
----	Q(27) REG-Earth Science	--	- / -	--	--	--
Q(26)*	Q(28) REG-Physics	.999	4 / 20	.967		
Q(27)*	Q(29) REG-Comp. Soc. Stud.	.79	4 / 20	.97		
Q(28)*	Q(30) Dropout	.03	6 / 100	**	**	**

Legend

Q(i)* = Goal Prog. Code — PRIORITY→ / WEIGHT WITHIN PRIORITY

Q(i) = Logistic Model Code

** = Error /no solution

N/A = Test not administered

TABLE 3.5B
SCENARIO 3 - CORRESPONDING FINANCIAL REQUIREMENTS

12/5/88
Corrected 12/6/88

G.P. Item No.	Logistic Model Item Code and Name		Current Allotment (Col. 1)	Goal Programming Solutions A. Current Budget (Col. 2)	B. Current Budget + 15% (Col. 3)	C. High Budget ($6685) (Col. 4)
	X(1) Instructional Chief School Adm. . . (per Total Enrollment)					
Y(1)	*X(2) Total Chief School Adm.		59.7	134.6		
	X(3) Instructional Salaries -----	ADMN./ IMPROV.				
	X(4) Non-Instruct. Salaries	"				
	X(5) Equipment/Supply	"				
	X(6) Contractual + BOCES	"				
	X(7) Total Curriculum Develop.	"				
	X(8) Total Supervision	"				
	X(9) Total Research/Education/Plan.	"				
	X(10) Total Training	"				
Y(2)	*X(11) Total Instr./Administ./Improv.	"	450.15	250.0		
	X(12) Teachers Salaries K-6 ----	INSTRUC.				
Y(3)	X(13) Teachers Salaries Total	"	2467.5	1953.0		
	X(14) Substitute Teacher Salaries	"				
Y(4)	X(15) Non-Instructional Salaries	"	38.9	0.0		
Y(5)	X(16) Equipment/Supply/Text Books	"	115.95	450.4		
Y(6)	X(17) BOCES/Contractual/Tuition	"	198.0	0.0		
Y(7)	*X(18) Total Instructional Teaching	"	2820.35	2368		
Y(9)	X(19) Instructional Salaries ----	MEDIA	88.2	59.0		
	X(20) Non-Instructional Salaries	"	20.80			
Y(9)	X(21) Equipment/Supply	"	49.40	660.0		
Y(10)	X(22) BOCES/Contractual	"	20.80	260.0		
Y(11)	*X(23) Total Instructional Media	"	165.45	979.0		
	X(24) Instructional Salaries ----	PUPIL SVS.				
	X(25) Non-Instructional Salaries	"				
	X(26) Equipment/Supply	"				
	X(27) BOCES/Contractual	"				
Y(12)	*X(28) Total Pupil Services	"	343.87	172.0		
	X(29) Instructional Salaries	"				
	X(30) Non-Instructional Salaries--	COCURRIC./ ATHLETIC				
	X(31) Equipment/Supply	"				
	X(32) BOCES Serv./Contractual	"				
Y(13)	*X(33) Total Cocurricular	"	13.35	[110.0]		
Y(14)	*X(34) Total Interscholastic Athletic	"	89.50	[218.0]		
Y(15)	*X(35) Total Cocurric./Athletic	"	102.85	328.0		
	X(36) Instructional Salaries ----	COMM. SVS.				
	X(37) Non-Instructional Salaries	"				
	X(38) Equipment/Supply	"				
	X(39) BOCES/Contractual	"				
Y(16)	X(40) Total Community/Recr.	"	0.0	0.0		
Y(17)	X(41) Total Youth Program	"	0.0	6.9		
	X(42) Total Civic Activities	"				
Y(18)	*X(43) Total Commun./Youth/Civic	"	.05	6.9		
Y(19)	*X(44) Total Emply. Benefit ----	OVERHEAD	1579.7	790		
	X(45) Total Operation & Maint.	"				
	X(46) Total Bus Transportation	"				
Y(20)	*X(47) Sum of [X(45) + X(46)]	"	1113.3	1400		

Legend
Y(i) = Goal Prog. Code
X(i) = Logistic Model Code
*X(i) = Summation Variable
[ ] = Suggested Allotment

results relative to these outcomes were not available. Finally, notice that all but targets Q^*_2 and Q^*_{21} are attainable. On the other hand, the corresponding financial resources (by category Y_1 - Y_{20}) needed to realize the attainable scholastic targets are tabulated in Table 3.5-B.

In this scenario the goal programming solutions call for less money to be spent on categories Y_2 and Y_{15} than on the same categories in scenarios 1 and 2. This phenomenon is due to the fact that the nonfinancial variables do influence the outcomes. Hence, the greater their numerical value, the less must be spent on administrative and cocurricular categories such as Y_2 and Y_{15}. Recall that the influence of the nonfinancial variables was accounted for by transferring them to the right hand side of the tableaux. Because the numerical value of the nonfinancial variables of the districts in question is higher than those found in scenarios 1 and 2, scenario 3 solutions call for a lesser amount of money to be spent on the said categories.

On the other hand, the goal programming model calls for a higher amount of money to be spent on category Y_{20}. This spending variation can be attributed to the district's size. The districts addressed in scenarios 1 and 2 are much larger and as such, they can exploit economies of scale. This district is not bestowed with such an economic advantage, inasmuch as it is 1/4 the size of the districts analyzed in scenarios 1 and 2. By contrast, the goal programming solutions regarding category Y_{19} is about half of the current allotment. As was anticipated, the Y_{19} solution is at the lower bound level inasmuch as this category was hypothesized to have little influence upon the desired targets. Finally, the model allocated $1,400 to category Y_{20} which is about 25% above the current allotment. This discrepancy can be attributed to the fact that the area in which this district is located is lacking necessary externalities that can be internalized by the district. It is also due to its size. In other words, due to its relatively small size (2,000 pupils) the school district lacks economies of scale.

D. Scenario 4 - Solutions

Scenario 4 represents a school district whose income per return ($35,000) is said to be above the statewide average and its enrollment is about 2,320 pupils. It was hypothesized that such a district could improve its current scholastic outcomes (while using its 1985 budget of $6631 per pupil) by merely applying a strategic planning technique as was advocated by Greenborough (1980). Hence, the goal programming solutions for this scenario are presented in Tables 3.6-A and 3.6-B.

A cursory examination of Table 3.6-A will reveal that test results were not available for outcomes Q^*_{15}, Q^*_{16}, Q^*_{21}, Q^*_{22} and Q^*_{23}. Also, solutions of dubious value were obtained for outcomes Q^*_{17} and Q^*_{28} and as such they are marked by (**). All other attainable outcomes are equal to or above the desired outcome levels.

The corresponding financial resources (by category) needed to realize the attainable outcomes are displayed in Table 3.6-B. While the current financial allotment (column 1) and the goal programming allocation (column 2) regarding category Y_3 (as denoted in this table) have a similar value, the other financial categories are vastly different in value. For instance, the current allotment for category Y_5 = $67.70, whereas the goal programming allocation for the same (category) is $638.00. Similarly, the current allotment and the goal programming allocation for category Y_9 are $14.20 and $185.00, respectively.

TABLE 3.6A
SCENARIO 4 - SCHOLASTIC ACHIEVEMENT

12/5/88
Corrected 12/6/88

				Goal Programming Solution		
		(Col. 1)	(Col. 2)	(Col. 3)	(Col. 4)	(Col. 5)
G.P. Item No.	Logistic Model Item Code and Name	Desired Scholastic Outcome	Priority/ Weight	Target Attained Under Current Budget	Target Attainable Under Current Budget + 15%	Target Attainable Under a Budget of $6685 Per enrolees
Q(1)*	Q(1) PEP-Reading Grade 3	.94	2 / 20	.94		
Q(2)*	Q(2) PEP-Math Grade 3	.96	1 / 33.3	.98		
Q(3)*	Q(3) PEP-Writing Grade 5	.99	2 / 20	.99		
Q(4)*	Q(4) PEP-Reading Grade 6	.98	2 / 20	.98		
Q(5)*	Q(5) PEP-Math Grade 6	.98	1 / 33.3	.98		
Q(6)*	Q(6) PCT-Reading Grade 6	.95	2 / 20	.97		
Q(7)*	Q(7) RCT-Math	.48	1 / 33.3	.91		
Q(8)*	Q(8) RCT-Reading	.52	2 / 20	.52		
Q(9)*	Q(9) RCT-Writing	.78	2 / 20	.99		
Q(10)*	Q(10) REG-Bookkeeping	.75	5 / 20	.75		
Q(11)*	Q(11) REG-Business Law	.83	5 / 20	.89		
Q(12)*	Q(12) REG-Business Math	.999	3 / 10	.999		
Q(13)*	Q(13) REG-Comp. English	.84	4 / 20	.98		
Q(14)*	Q(14) REG-Comp. French	.95	5 / 20	.97		
Q(15)*	Q(15) REG-Comp. German	N/A	5 / 20	N/A		
-----	Q(16) REG-Comp. Italian	--	- / -	--		
Q(15)*	Q(17) REG-Comp. Latin	N/A	5 / 20	N/A		
Q(17)*	Q(18) REG-Comp. Spanish	.92	5 / 20	.023		
Q(18)*	Q(19) REG-Math. 9	.38	3 / 20	.88		
Q(19)*	Q(20) REG-Math. 10	.74	3 / 15	.97		
Q(20)*	Q(21) REG-Math. 11	.86	3 / 10	.8599		
Q(21)*	Q(22) REG-Seq. Math I	N/A	3 / 20	N/A		
Q(22)*	Q(23) REG-Seq. Math II	N/A	3 / 15	N/A		
Q(23)*	Q(24) REG-Seq. Math III	N/A	3 / 10	N/A		
Q(24)*	Q(25) REG-Biology	.81	4 / 25	.95		
Q(25)*	Q(26) REG-Chemistry	.79	4 / 20	.99		
----	Q(27) REG-Earth Science	--	- / -	--		
Q(26)*	Q(28) REG-Physics	.82	4 / 20	.96		
Q(27)*	Q(29) REG-Comp. Soc. Stud.	.89	4 / 20	.99		
Q(28)*	Q(30) Dropout	.015	6 / 100	**		

Legend		
Q(i)* = Goal Prog. Code	PRIORITY→	/ WEIGHT WITHIN PRIORITY

Q(i) = Logistic Model Code

** = Error/no solution

N/A = Test not Administered

TABLE 3.6B
SCENARIO 4 - CORRESPONDING FINANCIAL REQUIREMENTS

12/5/88
Corrected 12/6/88

G.P. Item No.	Logistic Model Item Code and Name	Current Allotment (Col. 1)	Goal Programming Solutions A Current Budget (Col. 2)	B Current Budget + 15% (Col. 3)	C. High Budget ($6685) (Col. 4)
	X(1) Instructional Chief School Adm. (per Total Enrollment)	268.75	490.7		
Y(1)	*X(2) Total Chief School Adm.				
	X(3) Instructional Salaries ----- ADMN./IMPROV.				
	X(4) Non-Instruct. Salaries "				
	X(5) Equipment/Supply "				
	X(6) Contractual + BOCES "				
	X(7) Total Curriculum Develop. "				
	X(8) Total Supervision "				
	X(9) Total Research/Education/Plan. "				
	X(10) Total Training "				
Y(2)	*X(11) Total Instr./Administ./Improv. "	485.0	242.0		
	X(12) Teachers Salaries K-6 ---- INSTRUC.				
Y(3)	X(13) Teachers Salaries Total "	2273.0	2224.0		
	X(14) Substitute Teacher Salaries "				
Y(4)	X(15) Non-Instructional Salaries "	46.0	0.0		
Y(5)	X(16) Equipment/Supply/Text Books "	67.7	638.0		
Y(6)	X(17) BOCES/Contractual/Tuition "	83.4	113.0		
Y(7)	*X(18) Total Instructional Teaching "	2633.5	2975.0		
Y(8)	X(19) Instructional Salaries ---- MEDIA	124.2	140.0		
	X(20) Non-Instructional Salaries "				
Y(9)	X(21) Equipment/Supply "	14.2	185.0		
Y(10)	X(22) BOCES/Contractual "	26.75	317.0		
Y(11)	*X(23) Total Instructional Media "	192.9	643.0		
	X(24) Instructional Salaries ---- PUPIL SVS.				
	X(25) Non-Instructional Salaries "				
	X(26) Equipment/Supply "				
	X(27) BOCES/Contractual "				
Y(12)	*X(28) Total Pupil Services "	324.5	162.0		
	X(29) Instructional Salaries "				
	X(30) Non-Instructional Salaries-- COCURRIC./ATHLETIC				
	X(31) Equipment/Supply "				
	X(32) BOCES Serv./Contractual "				
Y(13)	*X(33) Total Cocurricular "	24.9	[200.0]		
Y(14)	*X(34) Total Interscholastic Athletic "	60.15	[401.0]		
Y(15)	*X(35) Total Cocurric./Athletic "	85.05	601		
	X(36) Instructional Salaries ---- COMM. SVS.				
	X(37) Non-Instructional Salaries "				
	X(38) Equipment/Supply "				
	X(39) BOCES/Contractual "				
Y(16)	X(40) Total Community/Recr. "	1.10	0.0		
Y(17)	X(41) Total Youth Program "	.80	29.5		
	X(42) Total Civic Activities "				
Y(18)	*X(43) Total Commun./Youth/Civic "	2.0	29.5		
Y(19)	*X(44) Total Emply. Benefit ---- OVERHEAD	1670	835.0		
	X(45) Total Operation & Maint. "				
	X(46) Total Bus Transportation "				
Y(20)	*X(47) Sum of [X(45) + X(46)] "	1107.6	554.0		

Legend
Y(i) = Goal Prog. Code
X(i) = Logistic Model Code
*X(i) = Summation Variable
[ ] = Suggested Allotment

In contrast, the current allotment and the goal programming allocation per category Y_{12} are \$324.50 and \$162.00, respectively. Similarly, the current allotment and the goal programming allocation for Y_{19} are respectively \$1670 and \$835, whereas the figures for Y_{20} are \$1107 and \$554, respectively.

These discrepancies can be explained in context of the nonfinancial and economic attributes of the district in question, as was discussed in the previous scenarios. Alternatively, one can compare the distribution of funds generated for this district by the goal programming technique to those of a property poor district, inasmuch as the budget in this case is similar in value to the high budget (\$6685) configuration of scenario 1. In doing so, the financial information found in Table 3.3-B could be compared with those found in Table 3.6-B, while ignoring (for the time being) the variation in the nonfinancial variables.

Hence, a cursory comparison of financial category Y_5 found in Table 3.3-B against the same, found in Table 3.6-B, will reveal a somewhat similar numerical value. This similarity seems to confer the prevailing practice of allocating funds for purchasing equipment and supplies only upon satisfying the resources needed for the (direct) instructional activities (e.g., Y_3) [see Hartman, 1985]. Supporting this view is the fact that under a lean budget configuration, no funds were allocated (by the goal programming) for category Y_5 [see Table 3.3-B, column 3].

By contrast, the goal programming model has allocated similar amount of money for category Y_{11}, whereas a dissimilar amount was allocated by this model to a related category, Y_{10}. Implicit in the contrasting allocations is the economy of scale notion. In other words, while both a small and a large district need similar amounts of money to provide instruction media services (Y_{11}), a greater benefit will be gained by the smaller district (scenario 4) if part of this service is provided by BOCES (Y_{10}). Similarly, Y_6 solutions reinforce this interpretation.

Finally, while the model allocated dissimilar amounts of monies to categories Y_{19} and Y_{20}, the figures for both districts are half of the current allotment (or at the lower bound levels). Hence, the solutions regarding Y_{19} confirm our initial hypothesis that this category has little bearing upon the realization of the scholastic outcome whenever a "trade-off" technique such as a goal programming is applied (in conjunction with the logistic model) to the resource allocation problems discussed thus far.

V. IMPROVEMENT OF THE RESOURCE ALLOCATION PROCEDURE

The premise behind this study was the belief that the effectiveness of a resource allocation procedure rested on the ability of the investigator(s) to capture relevant operational features of the educational entities, quantitatively. Hence, although results provided in the preceding pages are very promising, they could be improved through the utilization of:

- an improved model portraying the resources and scholastic outcomes relationships;
- alternative and related resource allocation procedures.

A. Modification of the Logistic Model

The logistic model is the foundation for the application of the resource allocation technique, discussed thus far, inasmuch as it is portraying certain input-output relationships of the educational process. To enhance the results obtained from the application of this approach, that model could be modified. In its current form, the model has a logistic structure, and as such, it can be dubbed as a "prospective" model. In addition to the suggestions found in Chapter Two, an improved model could be developed through the inclusion of "interactive" policy and lagged explanatory variables, in the equations of the logistic model. Consequently, the coefficients of these equations can be estimated through the application of the 2SLS technique suggested by Theil (1971).

B. Application of Related Resource Allocation Procedures

The goal programming technique used in this endeavor is a computational procedure which belongs to the field of multiobjective decision analysis. This field contains other relevant techniques (i.e., "prior articulation of preferences" techniques) that can be used instead of our current method. For instance, if a preemptive priority structure is felt to be too restrictive, a weighting scheme can be applied to all objectives at once rather than to subsets of objectives within priority classes. A "tradeoff" is, then, possible among all objectives to the degree specified by the weights. A particularly useful method to arrive at weights is the Analytic Hierarchy Process of Saaty (1982) which has its basis in pairwise comparisons. Another promising approach which requires progressive articulation of preferences is Compromise Programming developed by Zeleny (1973, 1974). This method optimizes each objective independently to form "ideal" solutions. The decision-maker is asked to make certain "compromises" and a new set of ideal solutions are formulated. This process continues until the feasible set of compromise solutions includes the "latest" ideal solution. Consequently, one can compare results obtained via these suggested methods against those generated by the goal programming technique. Alternatively, one can apply the DEA technique to this problem as was demonstrated by Bessent (1981), which determines the relative weights of outputs "optimally", and then compare results generated by this technique for reasonableness of prescribed policies against those generated by the schemes described above which require weighting information from the decision maker apriori or progressively.

VI. SUMMARY

In the preceding sections, the application of a goal programming technique to the problem of resource allocation within school districts, was discussed and the results of such an application were presented. In this section, a recapitulation of this effort is presented.

The objective of this endeavor was to demonstrate that a proven management science technique could be applied to the educational resource allocation problem. Results generated by the technique could then be used by the districts as criteria for allocating resources with respect to some prioritized educational targets. In the course of this effort the logistic model was used in conjunction with the goal programming technique to simulate various scenarios.

It should be noted however, that the solutions obtained for these scenarios presuppose that the material taught in a given academic subject is highly synchronized with the content of the corresponding state administrated test. Therefore changes in the content of such a test, which require a prolonged adjustment on the part of the schools, may influence the results generated by this approach. And, such a possibility must be considered by investigators who may wish to replicate this approach while using more recent data.

During the application of this strategic planning analysis to the resource allocation problems faced by nonmarket firms such as school districts, other economic notions were considered, namely:

- economies of scale;
- internalization of externalities;
- trade-off.

It was demonstrated in this study that these notions influence directly or indirectly the value of the scholastic outcomes. For instance, it was shown that the practice of internalizing externalities may reduce the amount of money needed for category Y_{20}. On the other hand, economies of scale play a role in the determination of the amount of money needed for Y_{19}, Y_6 and Y_{10}. Finally, the trade-off between nonfinancial attributes found in the districts and the available levels of budgetary configurations determined the amount of money needed to be allocated to each of the financial categories in order to ascertain the desired outcomes.

While the results of this endeavor are very revealing and promising, the approach discussed thus far can be improved through:

- utilization of an improved logistic model portraying financial resource utilization and scholastic outcomes relationships;
- application of related allocation procedures.

In sum, the application of the aforementioned approach should not be viewed as a mysterious process. Rather, it is an approach or a management tool which portrays the structure and behavior of certain education processes and consequently, could be used by educational decision makers to allocate resources needed for realizing prioritized educational goals. Finally, a similar approach could be used by the state to determine supplementary state aid for low performing districts.

4
SUMMARY & CONCLUSION

I. INTRODUCTION

II. THE PERSPECTIVE OF APPLIED RESEARCH METHODS

III. RECOMMENDATION FOR FUTURE RESEARCH

IV. CONCLUDING REMARKS

CHAPTER FOUR

SUMMARY AND CONCLUSIONS

I. INTRODUCTION

In the preceding chapters, the application of educational economic concepts and various quantitative methods to the problems of efficacious allocating of educational resources within school districts was discussed at length, whereas in this chapter a few concluding remarks concerning this endeavor are presented. As was noted in Chapter One, an attempt was made to use proven educational economics and management science concepts along with applied quantitative methods while analyzing the resource allocation problems within school districts. Hence, threaded throughout this report are concepts concerning:

- the structure, productivity and performance of the school districts as perceived by the nonmarket firm and productivity theories;
- a modified educational production function portraying the relationships between the quality of outcomes produced and resources used by the districts;
- the economics of resource allocation within school districts as perceived by the management science field of inquiry.

Thus, two empirical models were constructed. The first is a descriptive model composed of 28 logistic equations portraying the relationships between educational expenditures incurred, and the outcomes produced by school districts. A resource allocation procedure (goal programming) was then used in conjunction with this model. This amalgamated approach was used to determine the composition of financial resources needed to realize educational goals for various kinds of districts. These are operational as far as suburban school districts are concerned and the results obtained have led us to draw some inferences concerning the perspective of this and future applied research endeavors in the educational economics area.

II. THE PERSPECTIVE OF APPLIED RESEARCH METHODS

The central conclusion of the effort discussed thus far is that arrays of educational data can be reduced to a manageable set of equations through the application of the aforementioned concepts and techniques. Furthermore, it has been demonstrated that such an amalgamated approach can be used to summarize educational, economic and policy predicaments. Specifically, it has been demonstrated in this study that:

- o the relationships between educational means and ends can be quantified (into a model) through the application of the economic theory of Nonmarket Firms in conjunction with a logistic modeling approach;
- o multiobjective decision analysis techniques can be applied in conjunction with the above mentioned model to the problem of efficacious resource allocation within school districts so as to ascertain preemptive educational targets.

These techniques were chosen because of their unique properties. Specifically, they contain properties that simplify the construction of parsimonious models which are capable of providing voluminous information derived from a minimum number of basic variables [adapted from Spottheim, Oct. 28, 1988]. Also, it was felt that these techniques accurately portray the economic structure of the school districts. Since the logistic and goal programming models can tell us what scholastic performance and the corresponding productivity levels are attainable and what cannot be expected from the system, experimentation with alternative and costly methodologies was not necessary. Instead, a corrective course of action to enhance the performance of various types of schools can be inferred from the simulated solutions for the various types of schools' scenarios. Finally, the amalgamated research approach like the one used in this study has other advantages, stemming from the fact that its complementary techniques:

- explicitly defined assumptions, relationships and premises;
- can be used as a tool to trace the effects of a given resource upon a particular outcome;
- provide empirical solutions to real world educational problems;
- provide probable consequences of alternative solutions;
- are based on well-known and proven operations research and statistical techniques thereby allowing other researchers to replicate and test them in an analogous and/or different organizational setting [for detail see Ignizio, 1982; Lee, 1979; Draper, 1981; Fox, 1972; Spottheim/Wilson 1986-88; Spottheim, Oct. 28, 1988].

III. RECOMMENDATION FOR FUTURE RESEARCH

The suggested refinements discussed in earlier chapters are based on the assertion that the effectiveness of any applied (or empirical) methodology, rests on its ability to produce statistically relevant features concerning existing and/or anticipated policy predicaments that may be faced by the educational system under study. Thus, to enhance the operational capability of the two models, some further work was suggested. For instance, the logistic model presented in Chapter Two can be improved by recalibration of its equations through the application of Draper's (1981) centering technique. The goal programming model (Chapter Three) on the other hand, could be replaced and/or complemented by the compromise programming developed by Zeleny (1973, 1974) in conjunction with Saaty's (1982) technique. Finally, one could explore the applicability of the DEA approach to the performance and productivity problems faced by the public school system [see Bessent, 1982].

IV. CONCLUDING REMARKS

In sum, the application of the methodologies discussed thus far, should not be viewed as a mysterious process. Rather, it was demonstrated in the report how an array of educational data can be reduced to a manageable set of equations through the application of proven educational economic concepts and quantitative methods. Therefore it is believed that applied research methods should be used by the public educational sector to address prevailing administrative predicaments such as:

- what financial, socio-economic and other school district attributes are likely to enhance the performance of public education systems;
- what can be done to enhance the educational outcomes and performance of these entities;
- how to cope with the universal problem of inducing educators, administrators, and interest groups to forego self-serving opinions and discursive theories while pursuing the collective educational mission as depicted in the New York State Constitution; and
- how to assure the realization the state egalitarian obligation whose aim is to equip the New York State children with the necessary knowledge for their future roles as citizens in a democratic society and competitors in an avaricious market-oriented economy [adapted from Fox, 1972; Greenborough, 1980; Monk, 1980; Spottheim, Oct. 28, 1988; Tausky, 1978].

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